SUGAR BEET RESEARCH

1961 REPORT

Compiled by Sugar Beet Investigations

CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

CR-4-62

Copy for G. E. Coe

United States Department of Agriculture
Agricultural Research Service
Crops Research Division
Beltsville, Maryland

SUGAR BEET RESEARCH

1961 REPORT[1]

Compiled by Sugar Beet Investigations

1/ This is a progress report of cooperative investigations containing data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, ARS, U.S. Department of Agriculture, and the cooperating agency or agencies concerned.

CR-4-62

FOREWORD

Sugar Beet Research is an annual compilation of research accomplishments by staff members of Sugar Beet Investigations and by Cooperators.

The Report serves as a medium of presenting results of investigations that have been strengthened by contributions from the Beet Sugar Development Foundation and as a means of reporting research accomplishments under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers & Manufacturers Beet Sugar Association; Union Sugar Division, Consolidated Foods Corporation; and the California Beet Growers Association, Limited.

The pertinent Foundation Project has been indicated on the title page for various "Parts" of the Report. Some of the investigations reported by staff members of Sugar Beet Investigations, as well as by Cooperators, have not been supported by the Beet Sugar Development Foundation; therefore, a Foundation Project number on a title page should not be construed as meaning that all investigations received Foundation support.

Cooperators and cooperating agencies have been indicated for individual reports and on the title page of various Parts.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

HIGHLIGHTS OF ACCOMPLISHMENTS

New Facility for Sugarbeet Research.--The Crops Research Laboratory, located on the campus of Utah State University, Logan, Utah, was dedicated October 26, 1961. The staff of Sugar Beet Investigations occupies approximately 45 percent of the office and laboratory space and one of the two greenhouses presently available. This is the first Federal laboratory in which sugarbeet production research was provided for in the original plans and construction; therefore, the Logan facility represents a new era in Federal housing of sugarbeet investigations on breeding, genetics, physiology, and diseases. A photograph of the architectural rendering of the structures and the scenic environs is given on page 67.

The staff members of Sugar Beet Investigations formerly located at Salt Lake City, Utah, and at Twin Falls, Idaho, have been transferred to the Crops Research Laboratory. The moves have caused some interruption in research activities, but vigorous programs of basic investigations on regional problems in breeding, genetics, physiology, and plant pathology are being developed at the new location.

New Inbreds, Varieties, and Hybrids.--During 1961, Sugar Beet Investigations made available to the Beet Sugar Development Foundation 28 new developments in breeding research under provisions of a Memorandum of Understanding. The items proposed for seed increase and utilization have been described on pages 7-12. The plan of utilization of the items by members of the Foundation is given on pages 14-18. Small quantities of seed of most of the items proposed for increase were supplied to members of the Foundation, thereby permitting company breeders to explore the potential value of the items in their breeding programs.

Seed productions in 1961 of items proposed for seed increase in 1960 are given on page 19. Descriptions of the items proposed for seed increase and utilization in 1960 are given on pages 7-11 of the 1960 Report.

Through the Beet Sugar Development Foundation, 9 additional special items of breeding material developed by the staff of Sugar Beet Investigations were supplied to plant breeders of sugar companies.

Monogerm Seed Production.--The trend to monogerm seed in the United States is shown on page 16. The production records for 1956 through 1960 were taken from Agricultural Statistics, USDA. The preliminary estimate of the percentage monogerm in 1961 production is based on information supplied by seed companies and sugar companies producing sugarbeet seed.

Preliminary estimates of production indicate that approximately three-fourths of the seed crop in 1961 was monogerm--a remarkable advance since 1956 when only 3.7 percent was monogerm. The progressive trend to monogerm seed production is a reflection of the progress that has been made by sugarbeet

breeders of this country in the development of adapted monogerm varieties and hybrids. The accomplishments reported in previous issues of Sugar Beet Research have contributed significantly to the rapid development of monogerm varieties.

Productive Hybrids and Varieties.--The multigerm hybrids US H2, US H4, US H5, and US H6, which were developed by J. S. McFarlane, gave excellent performances in 1961 as in past years. The results of field trials by cooperators in the beet sugar industry and the results of other investigations conducted under his supervision are given in Part II.

Three-way crosses that have a male-sterile F_1 (MS of 7515 X 7569) as the monogerm parent gave gratifying performances in 1959, 1960, and 1961 (p. 23). The hybrid obtained when the male-sterile monogerm F_1 was pollinated with NB7 (0539) gave 17 to 24 percent more gross sugar than US 75. The sucrose percentage of the hybrid was also higher than that of US 75. This monogerm hybrid is equal to US 75 in curly top resistance and similar to US H6 in bolting resistance. The development of the parental material of this monogerm hybrid is a significant accomplishment in breeding research.

The excellent performances of the monogerm hybrids 9140 and 9122A and various other hybrids in tests conducted by G. K. Ryser and C. H. Smith in Utah, A. M. Murphy in Idaho, and K. D. Beatty at Brawley, California, indicate the wealth of basic breeding material (Part III) that is being developed under the supervision of F. V. Owen.

Variety evaluations in the Great Lakes region are reported in Part IV. The occurrence of leaf spot in the cooperative tests and throughout the region indicates that weather conditions in 1961 were unusually favorable for the development of the disease. The relative performances of the varieties, as summarized by G. J. Hogaboam (p. 88), were influenced by disease tolerance. The relative performances in acreable yield of roots and gross sugar of the new monogerm varieties SP 60194-01 and SP 60195-01, developed by G. E. Coe, can be attributed to their inherent defense against leaf spot damage.

Development of Inbred Lines and Basic Breeding Material.--The monogerm inbred line 0562, developed by J. S. McFarlane, has shown above-average performance in combining-ability tests. It is more resistant to curly top than US 75 and is more resistant to bolting than NB1. It is good in vigor and downy mildew resistance, and pollen production is adequate. The level of male sterility in the MS of 0562 is similar to that of the MS of NB1. The male-sterile equivalent of inbred 7569 (McFarlane) is being used extensively in the production of commercial monogerm hybrids. The hybrid, MS of 0562 X 7569, is a promising male-sterile monogerm F_1 for use as female parent in the commercial production of three-way crosses.

Breeder seed SP 6051-0, developed by G. E. Coe and cooperators in a coordinated program of breeding to establish parental material resistant to both leaf spot and curly top (p. 341), has shown a new level of combined tolerance to these major diseases. Under severe curly top exposure in a

[illegible] in the development of [illegible] mosaic-resistant varieties [illegible] accomplishments reported in previous issues of Sugar [illegible] were contributed significantly to the rapid development of [illegible].

[illegible]—The multigerm hybrids US H2, US H4, [illegible] were developed by J. S. McFarlane, have excellent [illegible] as in past years. The results of field trials by the beet sugar industry and the results of other investigations under his supervision are given in Part II.

Three-way crosses that have a male-sterile F_1 (of 7515 X 7504) as the [illegible] gave gratifying performances in 1959, 1960, and 1961 (p. 23). [illegible] obtained when the male-sterile monogerm F_1 was pollinated with [illegible] gave 17 to 24 percent more gross sugar than US 75. The sucrose percentage of the hybrid was also higher than that of US 75. The [illegible] hybrid is equal to US 75 in curly top resistance and similar to US 75 in bolting resistance. The development of the parental material of this monogerm hybrid is a significant accomplishment in breeding research.

The excellent performance of the monogerm hybrids 2149 and A1234 and other hybrids in tests conducted by C. W. Bauer and C. R. Haddock [illegible], J. R. Murphy in Idaho, and J. H. [illegible] at Brawley, California, [illegible] the wealth of basic breeding material (Part III) that is being [illegible] under the supervision of F. V. Owen.

Variety evaluations in the Great Lakes region are reported in Part IV. The occurrence of leaf spot in the cooperative tests was throughout the region [illegible] weather conditions in 1961 were unusually favorable for the development of the disease. The relative performance of the varieties, as summarized by G. J. Hogaboam (p. 60), were influenced by disease tolerance. The relative performance in acceptable yield of roots and gross sugar of the new monogerm hybrids SP 6014-01 and SP 60195-01, developed by G. E. Coe, can be attributed to their inherent defense against leaf spot.

Dr [illegible] Material.—The monogerm [illegible] developed by J. O. [illegible], has shown above-average [illegible] in combining ability tests. [illegible] is more resistant to curly top than US 35 and is more resistant to bolting than [illegible]. It is good in vigor [illegible] conditions, and [illegible] production is adequate. The level [illegible] in the US or [illegible] is similar to that of the US of [illegible]. [illegible] equivalent of hybrid 7535 [illegible] being [illegible] the [illegible] monogerm hybrids. The hybrid, [illegible] male-sterile monogerm F_1 for use as [illegible] production of [illegible] progenies.

[illegible] G. E. Coe and cooperators in a cooperative [illegible] established parental material varieties [illegible] 1961, has shown a new level of combined [illegible]. Under severe curly top exposure [illegible]

test conducted by A. M. Murphy (p. 127) at Jerome, Idaho, SP 6051-0 was strikingly more resistant than US 33 but not as resistant as SL 202H9. In the test conducted by J. C. Overpeck (p. 81) at University Park, New Mexico, curly top developed early in the season and leaf spot later reached epidemic proportions. The plot of SP 6051-0 appeared as a green island in a field where other entries showed severe foliage damage and death of plants. The replicated test by J. O. Gaskill (pp. 126 and 129) indicated a moderate level of productivity for SP 6051-0. Under leaf spot exposure the acreable yield of gross sugar of SP 6051-0 was significantly above that of SL 202H9.

Chemical Genetic Studies.--Cooperative research on chemical genetics involving 13 characters has been reported by LeRoy Powers in Part VI. He has presented current results as well as relevant information from several publications by him and coworkers. The summary (pp. 178-182) presents accomplishments and establishes limitations as well as attainable goals in breeding programs concerning chemical genetics of sugarbeets. Among other principles set forth in the report, it has been shown that adaptation to high levels of fertility in the sugarbeet is a trait that can be conditioned by genetic background.

Polyploidy.--Studies on the influence of ploidy are significant phases of breeding research by staff members at three stations. V. F. Savitsky (Part VII) has found that many sugarbeet populations show improvement in curly top resistance after they are tetraploidized, and concludes that an expression of genes conditioning curly top resistance will be optimum at the tetraploid level. According to G. E. Coe (p. 339), leaf spot resistance and root yield in triploids were related to the parent contributing the diploid gametes. B. L. Hammond (p. 59) has directed his efforts to the tetraploidization of basic breeding material developed by J. S. McFarlane. R. J. Hecker (p. 206) has found that diploid lines react differently with respect to root weight when converted to autotetraploids but that the tetraploid counterparts of lines tend to be higher in sucrose percentage than their diploid parent.

Colchicine treatments were shown by Helen Savitsky (p. 225) to be more effective in doubling chromosomes in epidermal tissue than in primordial tissues that produce sexual cells. Therefore, leaf characters such as size of stomata and number of chloroplasts in stomatal cells should be used only as preliminary screening techniques. Final determination should be based on diploid gamete selection as given in 1960 Report.

Interspecific Hybridizations.--Cytological studies by H. Savitsky (p. 229) have shown that, with some deviations, the development of inflorescences in *Beta patellaris*, *B. procumbens*, and *B. webbiana* follows the pattern of the multigerm sugarbeet. Therefore, hybridization does not produce monogerm progeny.

Virus Yellows Investigations and Breeding for Resistance.--Studies by J. E. Duffus (p. 286) have shown the relation of overwintered plants as a source of primary inoculum to the incidence and epidemiology of yellows

...ucted by A. M. Murphy (p. 127) at Jerome, Idaho, SP 8051-0 was ... more resistant than US 57 but not as resistant as SL 20289. In ... conducted by J. C. Overpeck (p. 81) at University Park, New Mexico, ... ly lot ... lapsed early in the season and leaf spot later reached epidemic ... tions. The plot of SP 8051-0 appeared as a green island in a field ... re other entries showed severe foliage damage and death of plants. The ... plicated ... st by J. O. Gaskill (pp. 126 and 129) indicated a moderate level of productivity for SP 6051-0. Under leaf spot exposure the acreable yield of gross sug... of SP 8051-0 was significantly above that of SL 20289.

...pu... ss.--Cooperative research on chemical genetics involv... ...ucrose has been reported by LeRoy Powers in Part VI. He has ... ubmed ... ment results as well as relevant information from several pub... ...ations by him and coworkers. This summary (pp. 172-182) presents accom... ...ns and actual steps limitations as well as attainable goals in breeding ... concerning chemical genetics of sugarbeets. Among other achievements set forth in the report, it has been shown that adaptation to high levels of fertility in the sugarbeet is a trait that can be conditioned by ge... background.

...Studies on the influence of ploidy are significant phases of ... ing research by staff members at three stations. G. K. Savitsky (Part VIII) has found that many sugarbeet populations show improvement in ... curly top resistance after they are tetraploidized, and concluded that an expression of genes conditioning curly top resistance will be optimum at ... loid level. According to C. L. Coe (p. 337), leaf spot resistance and ... yield in triploids were related to the parent contributing the diploid gametes. F. L. Hammond (p. 59) has directed his efforts to the ...ploidization of basic breeding material developed by J. S. McFarlane. ...l. Hecker (p. 206) has found that diploid lines react differently with respect to root weight when converted to autotetraploids but that the tetra-...loid counterparts of lines tend to be higher in sucrose percentage than their diploid parent.

Colchicine treatments were shown by Helen Savitsky (p. 225) to be more ... tive in doubling chromosomes in epidermal tissue than in primordial ... tissues that produce sexual cells. Therefore, leaf characters such as size of stomata and number of chloroplasts in stomatal cells should be used only as preliminary screening techniques. Final determination should be based on ... oid gamete selection as given in 1960 report.

...ogenetic ... ...--Cytological studies by H. Savitsky (p. 227) ... ...ecies ... evstation, the development of inflorescences in ... , and B. ... blana follows the pattern of the ... ...efore, hybridization does not produce monogerm

and mosaic in new sugarbeet plantings. This information has direct application in development of means of reducing damage from virus diseases, especially yellows in California.

Breeding for resistance to yellows has been approached by J. S. McFarlane, C. W. Bennett, and I. O. Skoyen (p. 319) through hybridization of curly top resistant lines with yellows resistant lines received from Dr. Henk Reitberg. In 1961, selections were made from segregating populations. Selections are also being continued from yellows tolerant lines derived directly from curly top resistant lines. Selections based on performance of infected seedlings in the greenhouse have been disappointing.

A field test was conducted to determine damage of beet yellows, western yellows, and a combination of the two viruses. In varieties and hybrids, beet yellows caused a reduction in root yields ranging from 15.8 to 33.1 percent. Combination of the two viruses reduced root yields 24.2 to 42.1 percent. A similar test was conducted in 1960. Beet yellows reduced the average yield of entries 23.8 percent in 1960 and 24.4 percent in 1961. A combination of beet and western yellows virus reduced average yields 33.9 percent in 1960 and 34.8 percent in 1961. Results of both years show that damages from beet yellows virus and from western yellows virus are additive.

Curly Top Investigations. In 1961 curly top symptoms were unusually severe in fields near Shandon, Las Barros, and Tracy, California. Tests were conducted by C.W. Bennett (p. 276) to determine whether more virulent strains were present. The striking virulence of a strain from Shandon is illustrated on page 280.

The occurrence of highly virulent strains of the curly top virus is of much concern. Insidiousness of new strains of pathogens usually permits their widespread distribution before the need for combating them is appreciated.

The marked increase in susceptibility to curly top, resulting from selections made by J. M. Fife (p. 318) on the basis of amino acid concentration, is extremely interesting.

Rhizoctonia Root Rot Investigations.--Investigations by J. O. Gaskill on breeding for resistance to *Rhizoctonia solani* is given in Part XI. Attention is directed to the encouraging performance of SP 611107-0 which was derived from a few surviving plants in a large population grown under severe exposure to the pathogen.

Breeding for Nematode Resistance.--Effective methods have been developed for greenhouse and field evaluations of breeding material for nematode resistance by Charles Price (Part IX) at Salinas, California. Progress is being made in the establishment of basic lines and varieties showing improvement in tolerance to *Heterodera schachtii* as well as tolerance to the combined attack of the nematode and other soilborne pathogens. Entries grown in crocks in 1961 showed average reduction of 18.8 percent in root weight, attributable to nematode inoculation of the soil. US 41 showed a reduction in root weight of 22.9 percent; 922A, a reduction of 50.9 percent; while entry 062-11 showed a reduction of only 0.8 percent.

Nematology Investigations.--Results of studies by A. E. Steele, Nematology Investigations, Crops Protection Research Branch, are given in Part VIII. He found that five leguminous crop plants did not show, for 1961, significant differences in the decline of cyst populations in microplots of soil infested with *Heterodera schachtii*. Root diffusates of resistant lines gave factors that were about as effective as those of the susceptible lines. In tests of 1961 it was found that Nabam at concentration of 4,000 ppm inhibited emergence of larvae from cysts of *H. schachtii*, as did sugar solution of 30 percent or above. When the cysts were transferred to tapwater, a considerable number of larvae emerged.

Leaf Spot Control.--Tests to determine the efficacy of oil and mixtures of oil and standard fungicides were conducted by C. L. Schneider (p. 351) and H. L. Bissonnette (p. 356). Tests at both locations showed significant increase in root yield for some of the fungicides. In the test at Beltsville, the average acreable yield of roots and mean sucrose percentage showed an increase for oil alone, but more effective control was obtained from applications of oil-fungicide mixtures. The treatments at Beltsville were applied at the rate of 1 gallon per acre with a Knapsack mist blower.

Tests conducted by H. W. Bockstahler (p. 118) at the Michigan Agricultural Experiment Station, showed that an average increase of 0.6 of a unit on the scale of leaf spot readings results in a reduction of 0.87 percentage units in sucrose.

Black Root.--The procedures developed by C. L. Schneider for greenhouse screening of breeding material for resistance to *Aphanomyces cochlioides* have been presented in Part XII. He has indicated the relative tolerances of various types of breeding material, including accessions of *Beta maritima*.

Physiological Investigations.--Investigations on nitrogen nutrition in relation to quality have been continued by Myron Stout (p. 360) in the greenhouse and field. Nitrates in the surface profile of the soil were considerably higher in recultivated strips than in the uncultivated area.

In studies by F. W. Snyder (p. 363), leaf area on August 1 correlated better with root weight and sucrose percentage than leaf area at harvest. Petiole determination indicated that carbon-^{14} applied to leaves is transported more rapidly under high nitrogen nutrition than under low nitrogen nutrition.

A useful method of root storage in polyethylene bags has been presented by C. H. Smith (p. 367).

Greenhouse Chambers for Seed Production.--Description of small, prefabricated greenhouse units, useful in the production of seed under isolation, has been given by J. S. McFarlane and I. O. Skoyen (p. 61). The chambers have proved satisfactory under conditions at Salinas, California.

[illegible] Studies.--Results of studies by A. E. Steele, Nematology [illegible] Research Branch, are given in Part VIII. [illegible] leguminous crop plants did not show, for 1961, significance in the decline of cyst populations in microplots of soil [illegible] Research subject. Root diffusates of resistant lines [illegible] were not as effective as those of the susceptible lines. [illegible] tests of 1961 it was found that Nabam at concentration of 4,000 ppm [illegible] of [illegible] from cyst [illegible] schachtii, a [illegible] tion of 30 percent or above. When the cysts [illegible] transferred to separation, [illegible] of larvae emerged.

[illegible] Co[illegible].--Tests to determine the efficacy of oil and mixtures [illegible] fungicides were conducted by C. L. Schneider (p. 351) and [illegible] L. Bissonnette (p. 356). Tests at both locations showed significant increase in root yield for some of the fungicides. In one test at Beltsville the average percentage yield of roots and gross sucrose percentage showed an increase for oil alone, but more effective control was obtained from applications of oil-fungicide mixtures. The treatments at Beltsville were applied at the rate of 1 gallon per acre with a Cummock mist blower.

Tests conducted by H. W. [redacted] (p. 110) at the [illegible] Agricultural Experiment Station, showed that an average increase of 0.6 of a unit on the scale of leaf spot readings results in a reduction of 0.8% percentage units in sucrose.

Black Root.--The procedures developed by C. L. Schneider for greenhouse screening of breeding material for resistance to Aphanomyces cochlioides have been presented in Part XII. He has indicated the relative contributions of various types of breeding material, including accessions of Beta patellaris.

[illegible] investigations.--Investigations on nitrogen nutrition in relation [illegible] have been continued by Myron Stout (p. 360) in the greenhouse [illegible] fields. Increases in the surface profile of the soil were consistently higher in unsubstituted strips than in the unsubstituted area.

In studies by F. W. Snyder (p. 363), leaf area on August 1 correlated [illegible] with root weight and sucrose percentage when leaf area at harvest. Results [illegible] tests indicated that carbon-14 applied to leaves is transported more [illegible] yield under high nitrogen [illegible] than under low nitrogen [illegible].

A useful method of root storage in polyethylene bags has been presented by C. [illegible] Smith (p. 367).

P A R T I

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase 1961
and
Utilization and Distribution of Items

- - -

Seed Production of 1960 Items

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase
May 23, 1961

Breeder seed, inbred lines, and varieties, which have been developed in the breeding research of Sugar Beet Investigations, are proposed for seed increase through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new products of breeding research have been developed by the staff of Sugar Beet Investigations in work conducted under Cooperative Agreements with:

Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Minnesota Agricultural Experiment Station
New Mexico Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.

Items Proposed for Seed Increase and Utilization

I. U.S. Sugar Beet Field Station, Salt Lake City, Utah.

Item 1. Monogerm CT5 (BC_1) Pollinator - - - - - - 3 pounds

A curly-top-resistant line recovered after first backcross to CT5 which it resembles. Line has good combining ability in crosses with multigerm male-sterile lines but does not appear to have the same combining ability in hybrids involving monogerm male-sterile lines. CT5 (BC_1) is very close to type-O, but it is not completely type-O. The line is recessive (rr) for hypocotyl color. (For description of CT5 multigerm, see Sugar Beet Research, 1957 Report, page 5.)

Item 2. Male-sterile of Monogerm CT5 (BC_1) - - - - - 2 pounds

Recovered after the first backcross to CT5 multigerm (see Item 1).

Item 3. Monogerm CT5 (BC_2) Pollinator - - - - - 1 pound

A line recovered after 2nd backcross to CT5 (see Item 1) and carefully indexed for type-O constitution. CT5 (BC_2) is recessive (rr) for hypocotyl color.

Item 4. Male sterile of Monogerm CT5 (BC_2) - - - - - 1 pound

Recovered after the 2nd backcross to CT5 multigerm (see Item 1).

Item 5. SLC 132, Monogerm Pollinator - - - - - 2 pounds

SLC is a poor pollen producer but has better vigor than many curly-top-resistant monogerm lines and shows good combining ability. The line is high in curly top resistance, rr genotype for hypocotyl color, and close to but not completely type-O.

In crosses to "superior male sterile" the progenies have been completely male sterile. The term "superior male sterile" signifies a male-sterile population obtained after backcrossing to a reliable type-O pollinator such as SLC 127, 128, or 129.

Item 6. SLC 132-O Monogerm - - - - - - 1 pound

SLC 132-O monogerm is the same as SLC 132mm, but seed from aa or Mendelian male-sterile plants. Approximately 20% aa segregates expected in progeny.

Item 7. SL 14460 (SLC 03) - - - - - - 2 pounds

Multigerm annual type-O pollinator. SL 14460 is a proven type-O pollinator and is useful for production of the superior male-sterile annual beet which in turn is used for indexing purposes.

Item 8. SL 14460HO - - - - - - - - - - 4 pounds

A superior multigerm male-sterile annual obtained by successive backcrosses to SLC 03.

Item 9. SL 14500 monogerm annual - - - - - - 1 pound

A pollinator that is nearly type-O construction but not completely so.

Item 10. SL 14500HO Monogerm Annual - - - - 1/2 pound

A male sterile obtained by backcrossing to SL 14500.

Item 11. Tetraploid US 104 Multigerm - - - - 1 pound

A tetraploid equivalent of US 104, developed by Dr. Helen Savitsky.

II. U.S. Agricultural Research Station, Salinas, California

Item 12. C1546 Monogerm - - - - - - 1 pound

A monogerm inbred with good resistance to both curly top and bolting. This inbred represents an increase of an F_3 selection from a cross between the bolting-resistant C8507mm and the NB6 inbreds. Combining ability tests are currently underway.

Suggested utilization: (a) Small increase of C1546 and (b) production of F_1 hybrid using C1546 as pollen parent and F61-562HO as seed bearing parent.

Item 13. C163T, 4n Multigerm - - - - - - 3 pounds

A tetraploid line developed from C663. Nine tetraploid plants were identified in the C_0 generation. The C_1 plants were checked cytologically and a small seed increase is being made at Salinas. Two triploid hybrids are also being produced for use in variety tests. An increase of C163T and the production of additional triploid hybrids are suggested for use in evaluation tests.
(Developed by Dr. Bayard L. Hammond.)

III. Sugar Beet Investigations, Fort Collins, Colorado.

Item 14. FC 501 Monogerm - - - - - - - 200 grams

A type-O monogerm, rr, S_2 inbred line with good leaf spot resistance and relatively good foliage uniformity and vigor. Roots are small and crowns tend to be high. The line may be useful to company breeders as a source of good leaf spot resistance combined with genes for the monogerm and type-O characters.

IV. Plant Industry Station, Beltsville, Maryland.

Item 15. SP 6121-0 Monogerm - - - - - - 2 pounds

A type-O line carrying good leaf spot resistance and moderate resistance to black root. The combining ability of the line as well as that of its male-sterile equivalent is not known.

Item 16. SP 6121-01(MS) Monogerm - - - - - - 4 pounds

Male-sterile equivalent of SP 6121-0.

Item 17. SP 6161-0 Monogerm - - - - - - 5 pounds

A monogerm synthetic variety derived from the interpollination of 6 clones. The first seed production was designated SP 6061-0, which had good black root resistance and excellent leaf spot resistance. Its performance at Beltsville was very similar to that of SP 5822-0.

In selecting parental clones for the synthesization of SP 6061-0, emphasis was placed on root yield. SP 6161-0 is a seed increase of SP 6061-0.

Item 18. SP 6162-0 Monogerm - - - - - - 5 pounds

A synthetic monogerm variety produced by the interpollination of 5 clones. The first seed production was designated SP 6062-0, which is similar to SP 6061-0 (see Item 17); but in selecting parental clones, emphasis was placed on sucrose percentage rather than on root yield. SP 6162-0 is a seed increase of SP 6062-0.

Item 19. SP 60194-01 Monogerm - - - - - - 5 pounds

A monogerm variety with moderate resistance to leaf spot and black root.

Note: SP 60194-01 and related varieties SP 60195-01 and SP 60196-01, which have similar breeding histories, are under field trial in 1961. The variety most attractive August 1 will be made available for seed increase and utilization.

V. Sugar Beet Investigations, East Lansing, Michigan, in cooperation with Michigan Agricultural Experiment Station.

Item 20. EL 61B18-0 Multigerm - - - - 1 pound

Seed production from 32 selected plants of hybrid SP 59B18-0. Selections were made on root size, leaf spot resistance, and frost tolerance. In two tests in Michigan (see Sugar Beet Research, 1960 Report, pages 287-290), SP 59B18-0 gave outstanding performances in root yield and frost tolerance, and in leaf spot resistance it was equal to SP 5822-0. The female parent of SP 69B18-0 was a self-sterile clone (Clone 02 00 00). The pollinator consisted of 7 clones going back to a stem mother (50232) from US 401.

Item 21. EL 61B28-01 Multigerm - - - - - 1 pound

EL 61B28-01 is a good increase of clone 02 00 00. This line is self sterile, and 27 vigorous clonal plants produced only 15 grams of seed. It is expected that 1 pound of seed will be obtained from approximately 250 stecklings that are growing in an isolated seed plot. This current production will be designated EL 61B28-01.

Item 22. EL 59B18-01 Monogerm - - - - - 1 pound

Open-pollinated seed harvested from the male parents of SP 58B18-0 (7 related clones from stem mother 50232 of US 401).

Suggested use: Increase separately to maintain parentage of SP 58B18-0 and mix EL 59B18-01 and EL 61B28-01 (Item 21) to duplicate SP 59B18-0.

Item 23. EL 61G1-01 Monogerm - - - - - 1 pound

A type-O monogerm line with some resistance to leaf spot and black root. EL 61G1-01 is the second sib generation of plant S_3 09-5-9-9, an identified type-O.

Item 24. EL 61G1X02 MS Monogerm - - - - - 80 grams

A male-sterile monogerm representing the 2nd backcross to EL 61G1-01 with Dr. Owen's annual indexer line serving as the source of male-sterile cytoplasm. Multigermness and the annual tendency of the indexer line have been removed from this population.

Item 25. EL 61G2-01 Monogerm - - - - - - - 1 pound

A type-O line with some resistance to leaf spot and black root. EL 61G2-01 is the second sib generation of plant S_3 09-5-16-14, an identified type-O.

Item 26. EL 61G2X02 MS Monogerm - - - - - - 30 grams

A male-sterile monogerm representing the 2nd backcross to EL 61G2-01 with Dr. Owen's annual indexer line serving as the source of male-sterile cytoplasm. Multigermness and the annual tendency of the indexer line have been removed from this population.

Item 27. EL 61G4-01 Monogerm - - - - - - - 1 pound

A type-O line with some resistance to leaf spot and black root. EL 61G4-01 is the second sib generation of plant S_3 09-7-32-25, an identified type-O.

Item 28. EL 61G4X02 MS Monogerm - - - - - - 1/2 pound

A male-sterile monogerm representing the 2nd backcross to EL 61G4-01 with Dr. Owen's annual indexer line serving as the source of male-sterile cytoplasm. Multigermness and the annual tendency of the indexer line have been removed from this population.

Note: In addition to the type-O monogerm lines EL 61G1-01, EL 61G2-01, and EL 61G4-01 (Items 23, 25, and 27), Dr. Hogaboam expects to have available two other type-O monogerm lines, EL 61G3-01 and EL 61G5-01, as well as their 2nd backcross male-sterile phases. If information obtained by August 1 indicates superiority of EL 61G3-01 or EL 61G5-01 over Items 23, 25, or 27, substitution will be made in seed supplied for increase.

VI. Breeding material developed by H. L. Kohls, Michigan Agricultural Experiment Station.

Item A. 60B-42 Multigerm - - - - - - - 1 pound

A selection made at Beltsville in 1959 for Mr. Kohls out of 57EL-42. This line carries black root resistance and a rather high degree of leaf spot resistance. It goes back to a selfed plant selected from a subline of 345.

Item B. 60EL-80 Multigerm - - - - - - - 1/2 pound

This line carries factors for smooth roots under a "sprangling stress," as well as factors for black root and leaf spot resistance. Seed produced on 5 Rr Yy plants.

<u>Note:</u> Items A and B are included in this listing with the permission of the Farm Crops Department, Michigan State University, and at the request of Mr. Kohls who would like to make these items available to the beet sugar industry.

BEET SUGAR DEVELOPMENT FOUNDATION

P. O. BOX 538
FORT COLLINS, COLORADO

UTILIZATION OF USDA SEED RELEASES, 1961

Numbers and items listed correspond to those listed in the USDA release memorandum dated May 23, 1961 1/

I. U. S. Sugar Beet Field Station, Salt Lake City, Utah

Item 1. Monogerm CT5 (BC_1) Pollinator

No joint increase of this release has been requested but distribution of a portion of the available quantity will be made as follows: Amalgamated Sugar Company, American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Utah-Idaho Sugar Company will each want at least 10 grams now. Separate requests for additional amounts may be received.

Item 2. Male Sterile of Monogerm CT5 (BC_1)

No joint increase of this release has been requested. A portion of the available quantity will be utilized in the same manner as for Item 1.

Item 3. Monogerm CT5 (BC_2) Pollinator

No joint increase of this release has been requested. A portion of the available quantity will be utilized in the same manner as for Item 1.

Item 4. Male Sterile of Monogerm CT5 (BC_2)

A portion of the available quantity will be utilized in the same manner as for Item 1. A .10-acre increase will be made by the Amalgamated Sugar Company from the balance available for the Amalgamated and Utah-Idaho Sugar Companies.

Item 5. SLC 132, Monogerm Pollinator

A portion of the available quantity will be utilized in the same manner as for Item 1. The balance will be utilized in the same manner as for Item 4.

Item 6. SLC 132-0 Monogerm

An increase of this item is to be made by the Utah-Idaho Sugar Company for the Utah-Idaho Sugar Company and the Farmers & Manufacturers Beet Sugar Association. No distribution will be made now unless a sufficient quantity remains after planting the increase.

1/ Proposals for seed increase and utilization from Dewey Stewart, Leader.

Item 7. SL 14460 (SLC 03)

No joint increase of this release has been requested. A portion of the available quantity will be utilized in the same manner as for Item 1.

Item 8. SL 14460HO

Originally an increase to approximately 200# of this number was requested. At this date, it appears that between 30 - 40# will be available. As consequence, individual requests for this number should be sent directly to Dr. Owen indicating the amount of seed desired. If requests exceed the amount available, an increase will be arranged for and partial distribution will be made now, proportionate to the requested amount.

Item 9. SL 14500 Monogerm Annual

No distribution of this release will be made at this time. Dr. Owen has been requested to use a reasonable quantity of the available seed for an increase to be distributed next year.

Item 10. SL 14500HO Monogerm Annual

No distribution of this release will be made at this time but will be increased in the same manner as for Item 9.

Item 11. Tetraploid US 104 Multigerm

The available quantity will be distributed equally among the companies listed under Item 1. No joint increase will be made.

II. U. S. Agricultural Research Station, Salinas, California

Item 12. C1546 Monogerm

No distribution of this number will be made at this time. The entire quantity will be used for increase by the West Coast Beet Seed Company and utilized as suggested. Distribution of the increase will be equal among American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Union Sugar Division.

Item 13. C163T, 4^N Multigerm

The following amounts will be distributed now to the companies listed: Union Sugar Division - 1/2 pound, Holly Sugar Corporation -- 1/2 pound, American Crystal Sugar Company - 100 grams, Utah-Idaho Sugar Company - 20 grams, Great Western Sugar Company - 20 grams, and Spreckels Sugar Company - 50 grams. One pound will be increased by the West Coast Beet Seed Company. The increase will be distributed identically with Item 12.

III. Sugar Beet Investigations, Fort Collins, Colorado

Item 14. FC 501 Monogerm

No joint increase of this release has been requested. Approximately 10 grams are to be distributed now to Amalgamated Sugar Company, American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Utah-Idaho Sugar Company. Requests for additional small amounts might be forthcoming.

IV. Plant Industry Station, Beltsville, Maryland

Item 15. SP 6121-0 Monogerm

No joint increase of this release has been requested. The available quantity is to be divided between Amalgamated Sugar Company, American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Utah-Idaho Sugar Company.

Item 16. SP 6121-01(MS) Monogerm

No joint increase of this release has been requested. The available quantity will be divided as noted for Item 15.

Item 17. SP 6161-0 Monogerm

Of the available quantity two pounds will be used for an increase by the West Coast Beet Seed Company. The increase will be equally divided between American Crystal Sugar Company, Great Western Sugar Company, Farmers & Manufacturers Beet Sugar Association and Holly Sugar Corporation. The amount not used for increase will be divided as noted for Item 15.

Item 18. SP 6161-0 Monogerm

The available quantity will be utilized as noted for Item 17.

Item 19. SP 60194-01 Monogerm

The available quantity will be utilized as noted for Item 17.

V. Sugar Beet Investigations, East Lansing, Michigan, in cooperation with Michigan Agricultural Experiment Station.

Item 20. EL 61B18-0 Multigerm

The available quantity will be divided among the following companies: Amalgamated Sugar Company, American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Utah-Idaho Sugar Company.

Item 21. EL 61B28-01 Multigerm

Of the quantity available, 50 grams are to be sent to the West Coast Beet Seed Company for planting in observational plots and the balance to Great Western Sugar Company for planting in Arizona. Stecklings from both these plantings will be divided between Great Western Sugar Company and Holly Sugar Corporation for plantings in mountain isolations. The seed from these increases will be available for later distribution.

Item 22. EL 59B18-01 Multigerm

All of the available quantity is to be used for increase by the West Coast Beet Seed Company for the Farmers & Manufacturers Beet Sugar Association.

Item 23. EL 61G1-01 Monogerm

Of the available quantity, 10 grams will be distributed to the following companies: Amalgamated Sugar Company, American Crystal Sugar Company, Farmers & Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company and Utah-Idaho Sugar Company.

Item 24. EL 61G1X01 MS Monogerm

The available quantity will be distributed as noted for Item 23.

Item 25. EL 61G2-01 Monogerm

The available quantity will be distributed as noted for Item 23.

Item 26. EL 61GX02 MS Monogerm

All of this seed will be left at East Lansing since an insufficient quantity is available for distribution. A few small requests can be filled. The number 61G2X03, a BC_1 equivalent from McFarlane's C 361 HO can be substituted upon request. This will segregate to give about 50% monogerm.

ITEM 27. EL 61G4-01 MONOGERM

THE AVAILABLE QUANTITY WILL BE DISTRIBUTED AS NOTED FOR ITEM 23.

ITEM 28. EL 61G4X02 MS MONOGERM

THE AVAILABLE QUANTITY WILL BE DISTRIBUTED AS NOTED FOR ITEM 23.

VI. BREEDING MATERIAL DEVELOPED BY H. L. KOHLS, MICHIGAN AGRICULTURAL EXPERIMENT STATION.

ITEM A. 60B-42 MULTIGERM

THIS QUANTITY OF SEED IS TO BE HELD FOR CONSIDERATION AT SOME LATER DATE.

ITEM B. 60EL-80 MULTIGERM

THIS QUANTITY OF SEED IS TO BE HELD FOR CONSIDERATION AT SOME LATER DATE.

1961 Seed Productions of 1960 Proposals for Seed Increase
(See 1960 Report, pp. 7-14)

1960 Proposals	1961 Production and Description of Items
Item 1	Monogerm SLC S-23 - No increase.
Item 2	Tetraploid US 401 - Increase by West Coast Beet Seed Co.
Item 3	SL 0410 (multigerm) - No increase.
Item 4	SL 010 (multigerm) - No increase.
Item 5	CT5A-0 (multigerm) - Increase by Utah-Idaho Sugar Co.
Item 6	CT5A (multigerm) - Increase by Utah-Idaho Sugar Co.
Item 7	SLC 129-0(rr)mm - Increase by Utah-Idaho Sugar Co.
Item 8	SLC 129 (monogerm) - Increase by Utah-Idaho Sugar Co.
Item 9	SLC 129MSmm - Increase by Utah-Idaho Sugar Co.
Item 10	SLC 133 (SL 7401)mm - Increase by Utah-Idaho Sugar Co.
Item 11	SLC 133MS (SL 7121) - Increase by Utah-Idaho Sugar Co.
Item 12) Item 13)	C 0562HOX C 0562mm - Increase (0.5 acre) by West Coast Beet Seed Co.
Item 14	C 0562H1 (monogerm)- No increase.
Item 15	SP 601000-0 (monogerm) - No increase.
Item 16	SP 6045-0 (monogerm) - Increase by West Coast Beet Seed Co.
Item 17	SP 60300-0 (monogerm) - Increase by West Coast Beet Seed Co.
Item 18	SP 5822-0 (multigerm) - Increase at Beltsville and by Great Western Sugar Co.

SUGAR BEET SEED PRODUCTION IN UNITED STATES, 1956-1961

Year of production	Multigerm	Monogerm	Total	Percent monogerm
	bags[1]	bags[1]	bags[1]	
1956	84,991	3,288	88,279	3.7
1957	83,812	10,735	94,547	11.4
1958	82,571	27,261	109,832	24.8
1959	83,594	28,194	111,788	25.2
1960	49,869	74,676	124,545	60.0
1961	Preliminary estimates indicate			76.7

1/ 100-pound bags.

There is a progressive trend toward monogerm varieties. In some areas, seed productions are essentially limited to monogerm varieties. The preliminary estimates of 1961 sugarbeet seed production in the United States indicate that approximately three-fourths of the crop is monogerm--a remarkable change in sugarbeet varieties in a period of 6 years.

PART II

DEVELOPMENT AND EVALUATION
of
INBRED LINES AND HYBRID VARIETIES OF SUGARBEETS SUITABLE FOR CALIFORNIA

Foundation Projects 24 and 29

J. S. McFarlane
B. L. Hammond
I. O. Skoyen
K. D. Beatty

Cooperators conducting tests:

American Crystal Sugar Company
Holly Sugar Corporation
Spreckels Sugar Company
Union Sugar Division
Southwestern Irrigation Field Station

REPORT ON FOUNDATION PROJECTS 24 AND 29

Summary of Accomplishments

PERFORMANCE OF MONOGERM INBREDS.--Combining ability tests with 0562, the monogerm inbred made available through the Foundation in 1960, indicate that above average performance can be expected when this inbred is used as a parent in commercial hybrids. Combining ability was determined from tests of the hybrid F57-85HO x 0562. This hybrid produced a gross sugar yield which averaged 114.7 percent of US 75 in twelve tests and 92.1 percent of US H6 in seven tests. The sucrose percentage averaged 102.3 percent of US 75 and 99.7 percent of US H6 in the same tests.

Curly-top resistance tests in both the field and greenhouse show 0562 to have the highest resistance of any monogerm inbred made available from Salinas. This resistance does not equal that of NB1 but is superior to that of US 75. Bolting resistance was superior to that of NB1 in tests both at Salinas and Tracy. Downy mildew resistance was very good in a Salinas test. The seed setting ability of 0562 was above average in Oregon. Plant vigor was good and pollen production was adequate. The MS of 0562 is a good male sterile similar to the MS of NB1.

The performance of 9561-4, a monogerm inbred made available in 1959, has been disappointing. Combining ability as determined from tests with the hybrid F57-85HO x 9561-4 was relatively poor. Additional increases of this line are not recommended.

Increases of 7515 and its male-sterile equivalent perform well in hybrid combinations but the inbred continues to give trouble in seed production. 0562 is being substituted for 7515 in test hybrids. If these test hybrids perform well, 7515 can be replaced by 0562 in commercial hybrid varieties.

Increases of 7569 and its male-sterile equivalent continue to perform well. The male-sterile equivalent of 7569 is being used extensively as the female parent in production of commercial monogerm hybrids. The F_1 hybrid MS of 0562 x 7569 has been produced and offers promise as a male-sterile monogerm parent. The curly-top resistance of this F_1 hybrid is intermediate between US 75 and MS of NB1 x NB3. Bolting resistance and combining ability are expected to be good based on the performance of the inbred components.

PERFORMANCE OF MONOGERM HYBRIDS.--Testing was continued with two monogerm hybrids, (MS of 7515 x 7569) x 663 and (MS of 7515 x 7569) x 0539. Most of the testing was done in the coastal valleys and in the Imperial Valley. A few tests were also made in the Central Valley. A summary of the performance of these two hybrids expressed in percent of the performance of US 75 follows:

Year	(MS of 7515 x 7569) x 663 No. of tests	Gross sugar	Sucrose percentage	(MS of 7515 x 7569) x 0539 No. of tests	Gross sugar	Sucrose percentage
1959	11	115	104	3	117	103
1960	23	109	102	4	124	103
1961	10	115	106	10	124	105

The results with (MS of 7515 x 7569) x 0539 are especially encouraging both from the standpoint of root yield and sucrose percentage. The performance of this hybrid compares favorably with that of the best multigerm hybrids. In nine of the 1961 tests the gross sugar yield averaged 104 percent and the sucrose percentage 101 percent of US H6. The curly-top resistance of this hybrid equals that of US 75, and the bolting resistance is similar to that of US H6. It can be grown in all areas except those subject to severe curly-top infection.

The hybrid (MS of 7515 x 7569) x 663 also performed well but tended to be inferior to the 0539 hybrid in yield, sucrose percentage, curly-top resistance, and bolting resistance.

Stock seed of all components of these hybrids have been produced, and a limited amount of commercial seed is being grown.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION.--A multigerm tetraploid, 163T, was made available in 1961. This tetraploid was produced by Dr. B. L. Hammond from the top cross parent 663. It represents an increase from nine plants identified as tetraploids in the C_0 generation. The C_1 plants were also checked cytologically. Triploid hybrids were produced between two diploid male steriles and 163T and will be evaluated in 1962 variety tests.

A new monogerm inbred, 1546, has been made available for seed increase. This inbred represents an increase of an F_3 selection from a cross between the bolting resistant 8507mm and the NB6 inbreds. Combining ability tests indicate that above average performance can be expected when this inbred is used as a parent in commercial hybrids. The curly-top resistance of 1546 is similar to that of 7569, and bolting resistance is expected to be good. It is not completely Type O, but hybrids with good male steriles such as the MS of 0562 should produce male-sterile progeny.

NB7 INBRED.--The 0539 multigerm inbred which was made available in 1960 has been designated NB7. This inbred is the increase of an S_4 line from a cross between a Type O selection of US 56 and NB1. It combines good curly-top resistance with moderate bolting resistance and has performed well as the pollen parent in combination with MS of 7515 x 7569. A tetraploid strain of NB7 has been produced by Dr. Hammond and is being increased and evaluated.

POLYPLOIDY.--Dr. Bayard L. Hammond has placed major attention on the production of tetraploids of superior bolting-resistant lines. These tetraploids will be used in producing triploid hybrids. Monogerm triploids will be produced by crossing tetraploid monogerm male steriles with diploid pollinators and by crossing diploid monogerm male steriles with tetraploid pollinators. Tetraploids have been produced in four of the more promising bolting-resistant monogerm inbreds and in MS of 0562. They have also been produced in several multigerm lines including the 663 top-cross parent, NB1, NB7, and in F57-85 and its male-sterile equivalent. A summary of this work, prepared by Dr. Hammond, is included in this report.

Triploid hybrids between bolting-resistant male steriles and European tetraploids were included in variety tests at Salinas, King City, and Brawley. The triploids were not superior to the better diploid hybrids in either root yield or sucrose percentage. Yields of the triploids were reduced by curly-top damage in the King City test. A triploid hybrid between a curly-top resistant diploid parent and a susceptible tetraploid parent was damaged more severely by curly top at Jerome, Idaho, than was a similar diploid hybrid. This was to be expected because the triploid contained two genomes from the susceptible parent and only one from the resistant parent.

Additional triploid hybrids were produced at Salinas and in Sweden between our male-sterile diploids and Swedish tetraploids. These triploids will be compared with our diploid hybrids in 1962 evaluation tests. Triploids involving the 663 tetraploid will also be tested.

CURLY TOP RESISTANCE.--Strains of the curly-top virus capable of causing severe damage to varieties currently classified as resistant have been identified by Dr. C. W. Bennett. This discovery points up the necessity for continued work on curly-top resistance. None of the USDA bolting-resistant monogerm varieties or male-sterile parents possess sufficient resistance for use in areas subject to heavy curly-top infection.

In the past all curly-top resistant selection work with US varieties and breeding lines has been done by Mr. A. M. Murphy at Jerome, Idaho. The work at Jerome was discontinued at the close of the 1961 season. Pending the establishment of a curly-top resistance selection program in Utah, greenhouse selection work has been started at Salinas in cooperation with Dr. Bennett.

Sugarbeet plants are grown in six-inch pots (4 plants to pot) and inoculated in the cotyledon stage with a curly-top strain of known virulence. Varietal resistance observed in the greenhouse agrees well with that observed in the field and selections can be made in segregating populations. Emphasis is being placed on development of monogerm inbreds resistant to the more virulent strains of the curly-top virus.

LEAF SPOT RESISTANCE.--The leaf-spot resistance of the male-sterile parents of bolting-resistant hybrid varieties was determined at Fort Collins, Colorado, by J. A. Elder and J. O. Gaskill. None of the male steriles were resistant but differences were observed in the degree of resistance. At the peak of the leaf-spot epidemic, the male steriles rated from 4.2 to 6.7 compared with a rating of 1.3 for US 201 (0 = no leaf spot: 10 = complete defoliation). The male-sterile equivalent of NB1 was the most severely damaged and the F_1 hybrids, MS of NB1 x NB4 and MS of NB1 x NB5, showed the least damage. The monogerm male steriles rated from 5.3 to 6.0. A table summarizing these results, prepared by Elder and Gaskill, is included in Part V of this report.

A group of S_2 segregates from crosses between a Type O plant from SP 5460-0 parental material and Type O bolting-resistant inbreds were also evaluated for leaf-spot resistance at Fort Collins. Some of these lines showed a high level of resistance, and selections were made for further increase and hybridization.

TYPE O SELECTIONS.--Indexing work was continued by I. O. Skoyen to develop Type O monogerm breeding lines. A total of 168 index progenies are being classified in the greenhouse at the present time. A large group of Type O monogerm lines have been identified and much of the monogerm breeding is now being done at the Type O level.

GERMINATION OF MONOGERM SEED.--Germination of many of the Oregon grown bolting-resistant monogerm seed lots was low in 1961. Low germination occurred not only in stock seed increases of inbred lines but also in commercial increases of monogerm hybrid varieties.

In past years, germination of some monogerm inbred increases has been low but serious germination problems with commercial bolting-resistant monogerm hybrids have not been experienced. Pollen production in monogerm inbreds is influenced by environment and is frequently poor when plants are grown under stress. Commercial US bolting-resistant monogerm hybrids are produced by crossing vigorous F_1 male-sterile monogerms with multigerm pollinators. This procedure greatly reduces the danger of low germination in the commercial seed. Germination of seventeen monogerm hybrids produced by this method between 1958 and 1960 ranged from 70 to 96 percent with an average germination of 84 percent. In contrast, the germination of eight 1961 commercial increases of similar monogerm hybrids ranged from 53 to 75 percent.

Reasons for low germination in 1961 have not been determined, but judging from the results of the past four years, these extremely low germinations are the exception rather than the rule.

Downy Mildew Resistance of Varieties and Inbreds

The past three years have been unfavorable for downy-mildew infection and information on resistance has not been obtained from tests designed for this purpose. A period of cool, humid weather occurred in early May and some mildew infection occurred in two yellows-resistance evaluation tests planted April 19. These two tests were grown side by side and infection was similar in both tests. Percent mildew infection from counts made by I. O. Skoyen are in Tables 1 and 2.

The NB4 inbred, which in earlier tests has shown good mildew resistance, was again resistant with only 0.1 percent infection. The 0716 inbred, a selection for yellows resistance from a cross between Type O US 56 and NB1, was highly resistant. Only 0.3 percent infection occurred in 0562 indicating that this new monogerm inbred line has good resistance. The selections from the European yellows-tolerant lines showed from 6.1 to 12.9 percent infection. The monogerm hybrid varieties (MS of 7515 x 7569) x 663 and (MS of 7515 x 7569) x 0539 were less severely infected than were any of the four European lines.

Table 1.--Occurrence of downy mildew in sugar beet hybrids, yellows resistant selections, and inbred lines at Salinas, California, in 1961.

No.	Description	Percent Mildew
Open-pollinated selections and hybrid varieties.		
028	Yel. res. sel. from IRS 55 M14	1.2
0539H1	(MS of 7515 x 7569) x 0539	1.7
F59-63H4	(MS of 7515 x 7569) x 663	2.3
026	Yel. res. sel. from A. C. 55-RF-393	4.2
027	Yel. res. sel. from IRS 55 M9	6.1
025	Yel. res. sel. from Hull's A7 S/1	11.0
023	Yel. res. sel. from Hull's L6 S/3	11.2
022	Yel. res. sel. from Hull's M9 S/2	12.9
Inbreds		
0716	Yel. res. inbred	0.1
0562	Monogerm inbred	0.3
0717	Yel. res. inbred	5.0
	L.S.D. at 5% point	3.0

Table 2.--Occurrence of downy mildew in sugar beet varieties and inbred lines at Salinas, California, in 1961.

No.	Description	Percent Mildew
Open-pollinated and hybrid varieties		
063H3	(MS of NB1 x NB4) x 663	0.5
F58-554H1	MS of NB1 x NB4	0.5
F60-547H1	MS of NB1 x NB5	0.6
5511H1	MS of NB1 x NB2	0.9
F57-68	US 75	1.0
011	Yellows res. sel. US 75	1.1
063H2	(MS of NB1 x NB5) x 663	1.1
063H1	(MS of NB1 x NB3) x 663	1.5
Inbreds		
6554	NB4	0.1
F60-547	MS of NB5	0.6
5502H1	MS of NB1	2.0
5511	NB2	2.5
	L.S.D. at 5% point	1.0

Bolting Resistance of Varieties and Inbreds

A group of varieties, F_1 hybrids, and inbreds were evaluated for bolting resistance at Salinas and Tracy, California. The Salinas tests were planted September 9 and November 4, 1960. The September test was planted without replication. The varieties and hybrids in the November test were replicated four times and the inbreds twice. The Tracy test was planted September 23, 1960, by Dr. D. D. Dickenson of the Holly Sugar Corporation, and the entries were replicated four times.

The 1960-61 season was favorable for the induction of bolting at both Salinas and Tracy. Bolting counts were made in each test at the time of maximum bolting and the results are in Table 1. The relative bolting resistance of both the varieties and inbreds varied from test to test. Variation within tests also tended to be high. Yellows was prevalent in all three tests and undoubtedly affected the amount of bolting.

The commercial hybrid varieties US H2, US H5, and US H6 bolted significantly more than did US 75 in the November planting at Salinas and at Tracy. The bolting-resistant hybrid variety (MS of NB5 x NB6) x F58-87 bolted the same as did US 75 in the November planting at Salinas and tended to be more bolting resistant than US 75 at Tracy. The monogerm hybrid (MS of 7515 x 7569) x 663 had similar resistance to US H2 in the Salinas November planting and also at Tracy. The new monogerm hybrid (MS of 7515 x 7569) x 0539 bolted similar to US H6 at both Salinas and Tracy.

Results with the inbred lines were variable. The bolting resistant NB1 inbred bolted 46 percent in the Salinas November planting compared with three percent in the Salinas September planting and twenty percent at Tracy. The monogerm 0562, which was made available in 1960, showed good resistance at both Salinas and Tracy. The new monogerm inbreds 0546-8, 0546-36, 0583-30, and 0583-34 were also resistant in the Salinas tests. The extremely bolting resistant NB6 inbred remained completely vegetative in all three tests.

The 1961 test, as well as those of previous years, has shown that the relative bolting resistance of varieties and inbreds is influenced by environment. It is probable that the optimum temperature for induction of bolting varies with the genotype. Germination tests have shown NB1 to have very little biological activity at temperatures below 45°F and it is conceivable that thermal induction is greatly reduced when temperatures are below 45°F. This could be one of the reasons that the relative bolting resistance of NB1 and some other lines vary greatly from one test to another. Bolting studies with homozygous lines under carefully controlled conditions are needed to clarify this problem.

Table 1

Percent bolting in sugar beet varieties and inbreds at Salinas and Tracy[1/]
California in 1961.

No.	Description	Salinas 9/9/60 planting	Salinas 11/4/60 planting	Tracy 9/23/60 planting
		Percent	Percent	Percent
Varieties and Hybrids				
368	US 75	52	6	39
F58-87	Bolt. res. sel. US 75	18	--	32
063H1	US H3	47	15	67
063H2	US H6	28	10	56
063H3	US H5	--	13	60
F59-63H4	(MS of 7515 x 7569) x 663	--	19	57
063H6	(MS of 7515 x 9561) x 663	--	23	62
087H1	(MS of NB5 x NB6) x F58-87	29	5	26
0539H1	(MS of 7515 x 7569) x 0539	39	11	55
F60-554H1	MS of NB1 x NB4	--	3	52
F60-512H1	MS of NB5 x NB6	12	2	10
F60-561H1	MS of 7615 x 9561-4	47	34	77
F60-561H2	F58-85HO x 9561-4	--	5	68
F59-569H1	MS of 7515 x 7569	22	23	63
0562H2	F58-85HO x 0562	--	3	52
0546-8H2	F58-85HO x 0546-8	25	2	51
0546-36H2	F58-85HO x 0546-36	--	2	37
	L. S. D. at 5% point	--	6.2	17.2
Inbreds				
5502	NB1	3	46	20
F59-502HO	MS of NB1	--	15	30
F60-512	NB6	0	0	0
0539	NB7	14	2	30
F59-515	Monogerm inbred	13	48	9
0562	Monogerm inbred	0	10	14
0562HO	MS of 0562	10-	7	34
F59-569HO	MS of 7569	13	--	31
F60-561HO	MS of 9561-4	18	14	46
F60-561HOA	" " "	14	12	57
0546-8	Monogerm inbred	7	4	--
0546-8HO	MS of 0546-8	36	2	--
0546-11	Monogerm inbred	29	10	--
-20	" " "	18	6	--
-36	" " "	7	4	--
0546-48	Monogerm inbred	24	13	--
0583-28	" " "	54	32	--
-30	" " "	5	3	--
-34	" " "	4	1	--
-44	" " "	19	10	--
	L. S. D. at 5% point	--	11.0	17.2

1/ Tracy test by Dr. D. D. Dickenson, Holly Sugar Corporation

Gross sugar yields of bolting-resistant hybrids in 1961
California variety tests, expressed in percent of the yield of US 75

Location	Testing Agency	US 75	US H2	US H4	US H5A	US H5B	US H6	F59-63H4 mm	0539H1 mm	0539H2 mm	087H1
Coastal Area											
Salinas - Nov. plt.	USDA	100	119	-	116	117	125	123	141	-	118
Salinas - Dec. plt.	"	100	-	-	111	119	124	119	134	130	116
King City - Test 1	Union	100	113	-	101	107	112	109	107	124	-
King City - Test 2	"	100	126	-	-	-	-	-	118	-	-
Betteravia	"	100	-	-	106	117	114	107	107	-	99
Spreckels	Spreckels	100	-	-	110	-	-	-	125	117	111
San Juan	"	100	-	-	-	121	123	113	-	-	115
Gilroy	"	100	-	-	-	-	114	117	-	-	-
Central Valley											
So. San Joaquin, Fall	Holly	100	-	98	-	-	119	-	-	-	103
Ryer Island	"	100	123	112	-	-	-	-	-	-	-
Staten Island	"	100	116	112	-	-	111	-	-	-	-
Hamilton City	"	100	119	105	-	-	113	-	-	-	-
Kern Lake	Spreckels	100	129	-	-	132	-	120	141	-	-
Ora Loma	"	100	106	-	-	85	-	-	-	-	91
Five Points	"	100	143	-	-	-	136	105	-	-	-
Imperial Valley											
Brawley - Early	USDA	100	126	-	112	-	121	113	120	109	-
Brawley - Late	"	100	124	-	106	-	118	115	115	106	-
Imp. Val. - Early	Holly	100	118	106	-	-	110	-	-	-	95
" " "	"	100	112	105	-	-	112	-	-	-	98
" " "	"	100	118	113	-	-	119	-	-	-	104
" " - Late	"	100	125	116	-	-	124	-	-	-	115
" " "	"	100	126	117	-	-	128	-	-	-	113
" " "	"	100	133	124	-	-	127	-	-	-	111
" " - Inter.	"	100	-	113	-	-	-	112	132	123	-

Sucrose percentage of bolting-resistant hybrids in 1961
California variety tests, expressed in percent of US 75

Location	Testing Agency	US 75	US H2	US H4	US H5A	US H5B	US H6	F59-63H4 [redacted]	0539H1 mm	0539H2 mm	087H1
Coastal Area											
Salinas - Nov. plt.	USDA	100	100	-	102	99	101	100	107	. -	99
Salinas - Dec. plt.	"	100	-	-	101	98	102	100	103	102	101
King City - Test 1	Union	100	104	-	107	103	106	104	102	102	-
King City - Test 2	"	100	104	-	-	-	-	-	101	-	-
Betteravia	"	100	-	-	104	103	101	102	101	-	96
Spreckels	Spreckels	100	-	-	105	-	-	-	122	111	104
San Juan	"	100	-	-	-	116	117	111	-	-	108
Gilroy	"	100	-	-	-	-	113	119	-	-	-
Central Valley											
So. San Joaquin, Fall	Holly	100	-	103	-	-	101	-	-	-	95
Ryer Island	"	100	100	102	-	-	-	-	-	-	-
Staten Island	"	100	102	106	-	-	101	-	-	-	-
Hamilton City	"	100	103	103	-	-	102	-	-	-	-
Kern Lake	Spreckels	100	102	-	-	98	-	105	102	-	-
Ora Loma	"	100	101	-	-	100	-	-	-	-	104
Five Points	"	100	104	-	-	-	102	101	-	-	-
Imperial Valley											
Brawley - Early	USDA	100	102	-	102	-	102	105	108	106	-
Brawley - Late	"	100	103	-	101	-	102	103	103	103	-
Imp. Val. - Early	Holly	100	105	106	-	-	106	-	-	-	103
" " "	"	100	104	106	-	-	103	-	-	-	99
" " "	"	100	104	108	-	-	103	-	-	-	103
" " - Late	"	100	102	105	-	-	101	-	-	-	99
" " "	"	100	105	111	-	-	105	-	-	-	105
" " "	"	100	105	112	-	-	105	-	-	-	102
" " - Inter	"	100	-	106	-	-	-	105	106	104	-

VARIETY TEST, BRAWLEY, CALIFORNIA, 1960-61

Location: Southwestern Irrigation Field Station.

Soil type: Holtville silty clay loam.

Previous crops: Grain sorghum, 1959; winter flax and fallow, 1959-60.

Fertilizer used: 100 lbs. per acre P_2O_5, preplant.
100 lbs. per acre nitrogen, actual, preplant.
100 lbs. per acre nitrogen, actual, applied after thinning.

Planting date: September 23, 1960.

Thinning date: October 10-13, 1960.

Harvest date: Early harvest, April 18-21, 1961.
Late harvest, May 31 - June 1, 1961.

Irrigations: Early harvest, six.
Late harvest, eight.

Diseases and insects: Curly top and yellows viruses were of minor importance in the 1960-61 test. One application of Thimet, 5-percent granular, made on January 5, 1961, for control of aphids, leafhoppers and spider mites. A second application of Thimet, 5-percent granular, on late harvested test was made March 31, 1961.

Experimental design: Randomized block with five replications, two-row plots; and randomized block with ten replications, single-row plots, for early harvest. Ten varieties planted in a 10 x 10 latin square for the late test. Varieties planted in two-row plots. Rows were spaced 30 inches apart. Plots 40 feet long.

Sugar analysis: From two 10-beet samples per plot by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California. Only three replications out of ten suitable for analysis of the single-row plot test. Poor stand and the border effect due to missing areas of plots forced abandonment of seven replications.

Plot under supervision of K. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1961

(5 replications of each variety) Harvested April 18-19, 1961

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Harvest Count
		Pounds	Tons	Percent	Number
F59-63H1	US H2	8,560	23.8	18.0	156
063H2	US H6	8,209	23.1	17.9	154
0539H1	7569H0 x 0539	8,199	21.7	19.0	150
F59-63H4	7569H0 x 663	7,680	20.9	18.5	164
0562H2	F58-85H0 x 0562	7,675	20.8	18.4	161
F59-86H3	US H5A	7,606	21.3	17.9	160
0539H2	9561H1 x 0539	7,393	19.9	18.7	158
0546-36H2	F58-85H0 x 0546-36	7,348	19.9	18.6	163
368	US 75	6,807	19.4	17.6	150
F60-561H2	F58-85H0 x 9561-4	6,573	17.9	18.4	158
General MEAN of all varieties in test		7,605	20.9	18.3	Beets per 100' row
S. E. of MEAN		246	0.97	0.39	
Significant Difference (19:1)		705	2.80	N.S.	
S. E. of MEAN in % of MEAN		3.23	4.67	2.13	

(Odds 19:1 = 2.03 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	1,917,594	15.24	0.94
Between replications	4	1,897,014	17.33	0.57
Remainder (Error)	36	301,525	4.75	0.76
Total	49			
Calculated F value		6.36**	3.21**	N.S.

** Exceeds the 1% point of significance (F=2.79)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1961

(10 x 10 Latin Square) Harvested: May 31-June 1, 1961

Variety No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
F59-63H1	US H2	11,606	31.7	18.3	161
063H2	US H6	11,021	30.6	18.0	161
0539H1	7569H0 x 8539	10,756	29.4	18.3	168
F59-63H4	8569H1 x 663	10,747	29.8	18.3	163
0562H2	F58-85H0 x 0561-16	10,311	28.0	18.4	166
0546-36H2	F58-85H0 x 0546-36	9,982	27.5	18.2	159
F59-86H3	US H5A	9,935	27.8	17.9	155
0539H2	9561H1 x 8539	9,921	27.1	18.3	165
368	US 75	9,353	26.4	17.7	153
F60-561H2	F58-85H0 x 9561-4	9,137	25.0	18.3	161
General MEAN of all varieties		10,277	28.3	18.2	Beets per 100' row
S. E. of MEAN		235	0.68	0.16	
Significant Difference (19:1)		663	1.91	N.S.	
S. E. of MEAN in % of MEAN		2.29	2.39	0.86	

(Odds 19:1 = 1.993 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	5,842,019	41.43	0.45
Between rows	9	2,492,014	18.43	0.64
Between columns	9	1,960,445	18.03	1.07
Remainder (Error)	72	553,030	4.60	0.25
Total	99			
Calculated F value		10.56**	9.01**	N.S.

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1961

(3 replications of each variety) Harvested: April 19-20, 1961

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
0583-30H1	F58-85H0 x 0583-30	8,438	23.2	18.2	68
0546-8H2	F58-85H0 x 0546-8	8,418	24.1	17.5	120
0539H3	F58-85H0 x 8539	8,139	22.5	18.1	68
0546-20H1	F58-85H0 x 0546-20	8,113	24.3	16.7	85
0546-22H1	F58-85H0 x 0546-22	8,073	22.3	18.1	95
0546-48H1	F58-85H0 x 0546-48	7,505	22.5	16.7	108
F59-63H1	US H2	7,490	20.3	18.5	110
0583-34H1	F58-85H0 x 0583-34	7,376	20.4	18.2	93
9921H3	7569H0 x H3611	7,372	20.2	18.3	85
0583-44H1	F58-85H0 x 0583-44	7,260	19.9	18.3	95
0583-28H1	F58-85H0 x 0583-28	7,145	20.3	17.6	108
0546-11H1	F58-85H0 x 0546-11	7,025	20.1	17.5	93
011	V.Y. sel. US 75	6,606	19.5	17.0	100
368	US 75	6,049	17.4	17.4	85
General MEAN of all varieties in test		7,501	21.2	17.7	Beets
S.E. of MEAN		387	1.19	0.318	per
Significant Difference (19:1)		1,125	3.47	0.92	100'
S.E. of MEAN in % of MEAN		5.16	5.63	1.80	row

Odds 19:1 = 2.056 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	13	1,426,350	11.53	1.12
Between replications	2	152,684	3.90	0.56
Remainder (Error)	26	449,224	4.28	0.30
Total	41			
Calculated F value		3.18**	2.69*	3.69**

*Exceeds the 5% point of significance (F=2.13)
**Exceeds the 1% point of significance (F=2.91)

VARIETY TEST, SALINAS, CALIFORNIA, 1961

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Previous crops: 1958, barley; 1959, fallow; 1960, vetch cover crop.

Fertilizer used: 660 lbs. per acre 10:10:5, preplant.
200 lbs. per acre ammonium sulfate sidedressed on December 1960 planting, March 31, 1961.
140 lbs. per acre ammonium sulfate sidedressed on November 1960 and December 1960 plantings, May 24, 1961.

Planting date: Bolting test planted November 4, 1960. Yield tests planted December 15, 1960.

Thinning date: Bolting test, December 29, 1961.
Yield tests, February 7, 1961.

Harvest date: Bolting test, September 5, 1961.
Yield tests, September 6-7, 1961.

Irrigations: At 7 to 10 day intervals with sprinkler system from early April to harvest.

Diseases and insects: Infection with yellows viruses approaching 100 percent by mid-May in 1961 tests. Heavy infestation of leaf miner occurred in early April. November and December plantings sprayed on April 23, May 3, and May 9, 1961 with Metacide-Dylox-brown sugar formulation for control of leaf miner.

Experimental design: Randomized block with four replications for the November planting. Varieties planted in two-row plots, plots 30 feet long. Randomized block with ten replications, plots 53 feet long, and randomized block with six replications, plots 44 feet long, for the December 1960 planting. Varieties planted in two-row plots with rows spaced 28 inches apart.

Sugar analysis: From two 10-beet samples per plot by Spreckels Sugar Company, Spreckels, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1961

(4 replicated plots of each variety)

Planted November 4, 1960
Harvested September 5, 1961

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
0539H1	(MS of 7515 x 7569) x 8539	12,372	39.2	15.8	11.3	175
063H8	(MS of 7515 x 8507) x 663	12,165	40.4	15.0	17.8	180
F60-554H1	(MS of NB1 x NB4)	11,875	40.0	14.9	2.6	176
063H9	(MS of 7569 x 8507) x 663	11,832	39.5	15.0	13.3	175
063H6	(MS of 7515 x 9561) x 663	11,515	38.3	15.0	23.3	178
0539H3	F58-85H0 x 8539	11,402	36.8	15.5	4.7	153
063H2	US H6	11,022	36.7	15.0	10.2	179
0546-48H1	F58-85H0 x 8546-48	11,017	37.0	14.9	8.9	158
F60-561H1	(MS of 7515 x 9561-4)	10,930	33.8	16.2	34.3	162
F59-63H4	(MS of 7515 x 7569) x 663	10,795	36.5	14.8	19.0	167
F60-547H1	(MS of NB1 x NB5)	10,785	34.6	15.6	5.2	175
F60-512H1	(MS of NB5 x NB6)	10,766	36.0	15.0	1.9	176
0546-22H1	F58-85H0 x 8546-22	10,700	35.1	15.3	6.4	152
F60-561H2	F58-85H0 x 9561-4	10,635	34.6	15.3	5.2	167
063H1	US H2	10,487	35.5	14.8	15.2	175
087H1	(MS of NB5 x NB6) x F58-87	10,396	35.7	14.6	4.6	170
063H3	US H5B	10,269	35.0	14.7	12.7	175
086H3	US H5A	10,233	34.0	15.1	17.2	157
0546-8H2	F58-85H0 x 8546-8	10,125	33.5	15.1	2.3	161
0546-36H2	F58-85H0 x 8546-36	10,006	34.2	14.6	2.3	167
F59-569H1	(MS of 7515 x 7569)	9,967	32.9	15.2	22.9	168
0546-11H1	F58-85H0 x 8546-11	9,708	31.3	15.5	9.8	153
0562H2	F58-85H0 x 0562	9,157	31.5	14.6	2.8	150
0583-44H1	F58-85H0 x 8583-44	8,920	32.7	13.6	9.1	149
368	US 75	8,794	29.8	14.8	5.3	168
0583-34H1	F58-85H0 x 8583-34	8,783	30.7	14.9	4.2	155
0583-30H1	F58-85H0 x 8583-30	8,402	28.2	14.9	2.7	154
0583-28H1	F58-85H0 x 8583-28	8,135	28.3	14.4	14.4	145
General MEAN of all varieties		10,400 1/	34.7	15.0	10.3	Beets per 100' row
S. E. of MEAN		261	1.3	0.11	1.84	
Significant Difference (19:1)		734	3.6	0.32	5.18	
S. E. of MEAN in % of MEAN		2.5	2.4	0.76	17.81	

(Odds 19:1 = 1.990 x $\sqrt{2}$ x Standard Error of MEAN)

1/ By short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	27	43.27	0.91	251.76
Between replications	3	2.40	0.10	45.39
Remainder (Error)	81	7.45	0.52	13.59
Total	111			
Calculated F value		5.81**	1.75*	18.53**

* Exceeds the 5% point of significance (F=1.63)

** Exceeds the 1% point of significance (F=1.99)

VARIETY TEST, SALINAS, CALIFORNIA, 1961

(10 replications of each variety)

Planted December 15, 1960
Harvested September 6-7, 1961

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
0539H1	(MS of 7515 x 7569) x 8539	10,923	35.5	15.4	1.1	170
063H2	US H6	10,127	33.3	15.2	1.8	167
F59-63H4	(MS of 7515 x 7569) x 663	9,733	32.8	14.9	1.6	172
063H3	US H5B	9,732	33.4	14.6	1.5	167
087H1	(MS of NB5 x NB6) x F58-87	9,442	31.5	15.0	0.7	163
086H3	US H5A	9,022	30.2	15.0	1.7	164
368	US 75	8,157	27.5	14.9	0.8	173
General MEAN of all varieties in test		9,591	32.0	15.0	1.3	Beets per 100' row
S. E. of MEAN		187 1/	0.45	0.20	0.11	
Significant Difference (19:1)		526	1.27	N.S.	N.S.	
S. E. of MEAN in % of MEAN		1.95	1.40	1.36	8.46	

Odds 19:1 = 1.989 x $\sqrt{2}$ x Standard Error of MEAN

1/ By short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Tons Beets	Percent Sucrose	Percent Bolters
Between varieties	6	67.7	0.69	2.04
Between replications	9	17.4	0.57	1.14
Remainder (Error)	54	2.0	0.42	1.24
Total	69			
Calculated F value		33.51**	N.S.	N.S.

** Exceeds the 1% point of significance (F=3.15)

VARIETY TEST, SALINAS, CALIFORNIA, 1961

(6 replications of each variety)

Planted: December 15, 1960
Harvested: September 6-7, 1961

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
9953-5	(MS of 7515 x 7569) x D-43	10,556	35.7	14.8	1.6	149
063H8	(MS of 7515 x 8507) x 663	10,415	34.4	15.2	2.5	176
0539H2	(MS of 7515 x 9561) x 8539	10,409	34.5	15.1	3.9	165
063H9	(MS of 8569 x 8507) x 663	10,338	34.8	14.9	0.7	172
9952-4	(MS of NB1 x NB4) x D-38	10,078	34.7	14.5	5.1	149
063H2	US H6	9,918	33.1	15.0	1.6	172
0562H2	F58-85HO x 0562	9,802	32.4	15.1	0.8	166
0546-48H1	F58-85HO x 8546-48	9,702	32.8	14.8	0.7	163
0546-22H1	F58-85HO x 8546-22	9,494	31.6	15.0	0.9	155
Polybeta	German Polyploid	9,398	30.6	15.3	8.8	152
0546-36H2	F58-85HO x 8546-36	9,383	31.3	15.0	0.2	163
0546-8H2	F58-85HO x 8546-8	9,222	30.5	15.1	0.1	159
0546-11H1	F58-85HO x 8546-11	9,060	30.2	15.0	0.7	159
F60-561H2	F58-85HO x 8561-4	9,007	29.3	15.4	0.0	166
011	V. Yel. sel. from US 75	8,826	29.8	14.8	2.1	165
0583-44H1	F58-85HO x 8583-44	8,063	27.3	14.8	0.4	158
368	US 75	7,988	26.9	14.8	0.6	165
0583-30H1	F58-85HO x 8583-30	7,898	26.4	15.0	0.1	154
0583-34H1	F58-85HO x 8583-34	7,873	27.0	14.6	0.1	157
0583-28H1	F58-85HO x 8583-28	7,337	25.7	14.3	1.5	156
General MEAN of all varieties		9,238	30.9	14.9	1.6	Beets per 100' row
S. E. of MEAN		481 1/	1.53	0.24		
Significant Difference (19:1)		1,349	4.29	N.S.		
S. E. of MEAN in % of MEAN		5.20	4.95	1.61		

(Odds 19:1 = 1.984 x $\sqrt{2}$ x Standard Error of MEAN)

1/ By short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Between varieties	19	58.6	0.44
Between replications	5	40.7	1.27
Remainder (Error)	95	14.0	0.35
Total	119		
Calculated F value		4.18**	N.S.

** Exceeds the 1% point of significance (F=2.09)

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1961

(6 replications of each variety) By American Crystal Sugar Co.

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
0539H1	(MS of 7515 x 7569) x 0539	5,446	22.05	12.35	136
063H8	(MS of 7515 x 8507) x 663	5,095	18.36	13.88	138
F59-63H4	(MS of 7515 x 7569) x 663	4,855	18.76	12.94	126
063H9	(MS of 7569 x 8507) x 663	4,823	16.88	14.28	140
60-801	Reselection of 58-304	4,770	18.17	13.13	144
0562H2	F58-85H0 x 0562	4,761	18.12	13.14	126
60-807	Reselection of 58-808	4,704	16.46	14.29	138
Am #5 ND	Commercial variety	4,510	16.25	13.88	143
063H2	(MS of NB1 x NB5) x 663	4,405	17.19	12.81	143
General MEAN		4,819	18.03	13.37	137
LSD 5%		547	1.71	0.90	Beets
LSD 1%		---	2.28	1.20	per
Calculated F value		2.58*	8.57**	4.75**	100'
C. V. %		9.74	8.12	5.72	row

*Exceeds the 5% point of significance (F=2.02)
**Exceeds the 1% point of significance (F=2.70)

Cooperator: Joseph Borges
Location: Freeport
Planted: February 27, 1961
Harvested: September 26-27, 1961
Experimental design: 9 x 6 randomized block. Plot test E.

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1961

(6 replications of each variety) By American Crystal Sugar Co.

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
F60-561H2	F58-85HO x 9561-4	4,827	18.04	13.38	146
F60-561H1	F58-515HO x 9561-4	4,772	19.83	12.03	149
60-GH #5-M-1	Comp. NB varieties	4,701	17.58	13.37	151
Am #2 Hybrid	(MS of NB1 x NB3) x 54-406-0	4,618	16.50	13.99	155
F60-512H1	(MS of NB5 x NB6)	4,499	16.54	13.60	131
Am #5 NB	Commercial variety	4,368	16.08	13.59	159
F60-561HO	MS of 9561-4	4,206	16.15	13.02	133
F60-561HOA	MS of 9561-4	4,115	14.93	13.79	166
F60-547H1	(MS of NB1 x NB5)	3,949	13.72	14.39	136
General MEAN		4,451	16.59	13.41	147
LSD 5%		---	2.01	0.87	Beets
LSD 1%		---	2.69	1.17	per
Calculated F value		NS	6.33**	4.67**	100'
C. V. %		11.64	10.38	5.56	row

*Exceeds the 5% point of significance (F=2.02)
**Exceeds the 1% point of significance (F=2.70)

Cooperator: Joseph Borges
Location: Freeport
Planted: February 27, 1961
Harvested: September 26-27, 1961
Experimental design: 9 x 6 randomized block. Plot test D.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1961

First planting - September 10, 1960

By Holly Sugar Corporation

Variety	Description	Gross sugar 1st.har. Pounds	Gross sugar 2nd.har. Pounds	Gross sugar 3rd.har. Pounds	Tons per acre 1st.har. Tons	Tons per acre 2nd.har. Tons	Tons per acre 3rd.har. Tons	Sucrose 1st.har. Percent	Sucrose 2nd.har. Percent	Sucrose 3rd.har. Percent
Lot 9381	US H2	7,048	9,013	10,812	23.75	27.78	35.24	14.84	16.22	15.34
F59-63H2	US H6	6,586	9,041	10,894	22.04	28.10	35.86	14.94	16.09	15.19
Lot 9374	US H4	6,338	8,455	10,340	21.14	25.51	32.48	14.99	16.57	15.92
Lot 817	US 75	5,998	8,064	9,158	21.21	25.76	31.17	14.14	15.65	14.69
887H5	(MS of NB6 x NB5) x 787	5,694	7,929	9,559	19.61	25.46	31.62	14.52	15.57	15.12
General MEAN of all varieties in test		6,390	8,548	10,262	21.85	26.96	33.62	14.62	15.85	15.26
S. E. of MEAN		193A/	175A/	168A/	0.59	0.45	0.47	0.20	0.19	0.13
Significant Difference (19:1)		542	492	472	1.65	1.26	1.32	0.57	0.53	0.37
S. E. of MEAN in percent of MEAN		3.02	2.05	1.64	2.68	1.67	1.40	1.38	1.19	0.86

Variety	Description	Thin juice purity 1st.har. Percent	Thin juice purity 2nd.har. Percent	Thin juice purity 3rd.har. Percent	Bolting 1st.har. Percent	Bolting 2nd.har. Percent	Bolting 3rd.har. Percent	Harvest count per 100' row 1st.har. Number	Harvest count per 100' row 2nd.har. Number	Harvest count per 100' row 3rd.har. Number
Lot 9381	US H2	90.98	90.77	90.01	---	4.5	3.1	178	165	167
F59-63H2	US H6	90.89	88.74	89.05	---	0.6	0.9	183	155	169
Lot 9374	US H4	90.34	89.67	89.95	---	0.8	1.1	173	161	167
Lot 817	US 75	89.67	88.60	88.21	---	0.4	0.6	183	156	168
887H5	(MS of NB6 x NB5) x 787	89.54	87.83	88.46	---	---	0.3	173	155	172
General MEAN of all varieties in test		90.39	88.85	89.38				179	157	169
S. E. of MEAN		0.54	0.54	0.40						
Significant Difference (19:1)		N.S.	1.51	1.11						
S. E. of MEAN in percent of MEAN		0.60	0.61	0.44						

Harvest dates: April 5, 1961; May 17, 1961; June 15, 1961.
A/ By short cut formula.
Cooperator: Nelson Correll
Design: 3 x 4 Rectangular lattice with 9 replications.
Plot size: Two-rows spaced 34 inches apart and 53 feet long.
Two-rows x 50' harvested.

Results extracted from tests of 12 varieties.

Agricultural Research Department
Holly Sugar Corporation

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1961

Second planting - October 10, 1960

By Holly Sugar Corporation

Variety	Description	Gross sugar 2nd.har. Pounds	Gross sugar 3rd.har. Pounds	Gross sugar 4th.har. Pounds	Tons per acre 2nd.har. Tons	Tons per acre 3rd.har. Tons	Tons per acre 4th.har. Tons	Sucrose 2nd.har. Percent	Sucrose 3rd.har. Percent	Sucrose 4th.har. Percent
Lot 9381	US H2	7,471	9,286	9,115	24.24	33.12	34.53	15.41	14.02	13.20
F59-63H2	US H6	7,383	9,445	8,754	24.21	33.85	33.41	15.25	13.95	13.10
Lot 9374	US H4	6,918	8,655	8,537	21.86	29.20	30.55	15.82	14.82	13.97
887H5	(MS of NB6 x NB5) x 787	6,849	8,374	7,625	22.89	30.04	29.86	14.96	13.94	12.77
Lot 817	US 75	5,968	7,394	6,866	19.81	27.74	27.42	15.06	13.33	12.52
General MEAN of all varieties in test		6,954	8,582	8,190	22.95	30.69	31.21	15.15	13.98	13.12
S. E. of MEAN		182A/	204A/	168A/	0.52	0.67	0.51	0.20	0.13	0.16
Significant Difference (19:1)		511	573	472	1.46	1.87	1.44	0.56	0.38	0.45
S. E. of MEAN in percent of MEAN		2.62	2.38	2.05	2.26	2.17	1.64	1.30	0.96	1.23

Variety	Description	Thin juice purity 2nd.har. Percent	Thin juice purity 3rd.har. Percent	Thin juice purity 4th.har. Percent	Bolting 2nd.har. Percent	Bolting 3rd.har. Percent	Bolting 4th.har. Percent	Harvest count per 100' row 2nd.har. Number	Harvest count per 100' row 3rd.har. Number	Harvest count per 100' row 4th.har. Number
Lot 9381	US H2	88.49	88.98	89.99	---	---	0.3	183	183	170
F59-63H2	US H6	89.12	88.34	89.32	---	0.1	0.1	181	184	181
Lot 9374	US H4	88.88	89.13	90.79	---	0.3	---	182	182	177
887H5	(MS of NB6 x NB5) x 787	88.93	87.91	89.27	---	0.1	---	178	178	175
Lot 817	US 75	88.30	88.08	88.49	---	---	0.1	179	183	175
General MEAN of all varieties in test		88.74	88.72	89.64				180	181	173
S. E. of MEAN		0.63	0.45	0.45						
Significant Difference (19:1)		N.S.	N.S.	1.27						
S. E. of MEAN in percent of MEAN		0.71	0.51	0.51						

Harvest dates: May 18, 1961; June 17, 1961; July 21, 1961.

A/ By short cut formula.

Cooperator: Nelson Correll

Design: 3 x 4 Rectangular lattice with 9 replications.

Plot size: Two-rows spaced 34 inches apart and 53 feet long.
Two-rows x 50' harvested.

Results extracted from tests of 12 varieties.

Agricultural Research Department
Holly Sugar Corporation

Variety Test | 1961 | Imperial Valley

Intermediate Date of Planting | Coop: Nelson Correll

Variety	Source	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P.	% Bolt.	No. Beets 100' Row
0539H1	7569H0 x 8539	9584	34.060	14.07	89.37	.0	194
0539H2	9561H1 x 8539	8944	32.173	13.90	89.77	.1	203
063H7	9561H3 x 663	8566	30.879	13.87	89.09	.0	209
063H6	9561H1 x 663	8288	29.944	13.84	88.64	.1	193
0562H2	F58-85H0 x 0562	8275	30.289	13.66	87.29	.0	170
USH4	L9374	8200	29.038	14.12	89.42	.0	184
F59-63H4	8569H1 x 0863	8165	29.202	13.98	88.67	.0	205
0546-36H2	F58-85H0 x 9546-36	7819	28.811	13.57	88.27	.1	169
US75	L817	7287	27.353	13.32	88.06	.0	194
F60-561H2	F57-85H0 x 9561	7026	25.908	13.56	87.95	.0	181
0546-8H2	F58-85H0 x 9546-8	6980	27.098	12.88	89.01	.0	166
Gen. Mean		8186	30.182	13.56	88.46		183
SE mean		211 A/	.607	.22	.60		
LSD (5%)		588	1.693	.61	NS		
SEm/Gen. Mean (%)		2.57	2.01	1.61	.68		

Variance Table

Variation Due To	DF	Mean Squares: Tons Beets	Mean Squares: % Sucrose	Mean Squares: % T.J.P.
Replication	8	15.614	3.357	4.238
Variety	24	34.283	1.297	4.727
Error	192	3.319	.427	3.268
Total	224			
Calc. F		10.33**	3.04**	NS

** Exceeds 1% point 1.88
A/ Short Cut Formula
NS Not Significant

Design: 5 x 5 Triple Lattice - 9 reps.
Plot Size: 2 rows (34") x 53' Planted
2 rows x 50' Harvested
Planted: October 10, 1960
Harvested: June 14, 1961

Above results extracted from a test of 25 varieties

Variety Test 1961 South San Joaquin

South San Joaquin Fall Coop: McAlister

Variety	Source	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P. 1/	% Bolt.	No. Beets 100' Row
USH6	(NB1MS x NB5) x C663	11956	42.914	13.93		15.5	153
0562H2	F58-85HO x 0562	10890	39.890	13.65		16.1	140
887H5	(NB6MS x NB5) x C787	10377	39.457	13.15		11.0	155
F60-561H2	F57-85HO x 9561	10165	36.303	14.00		23.9	144
US75	L9252	10079	36.439	13.83		15.6	156
USH4	L0336	9866	34.714	14.21		17.7	149
Gen. Mean		10570	38.680	13.68			150
SE mean		297 A/	.718	.29			
LSD (5%)		831	2.009	.81			
SEm/Gen. Mean		2.81	1.86	2.11			

Variance Table

Variation Due To	DF	Mean Squares: Tons Beets	% Sucrose	% T.J.P.
Replication	8	46.945	2.600	
Variety	15	92.315	2.289	
Error	120	4.636	.748	
Total	143			
Calc. F		19.91**	3.06**	

** Exceeds 1% point 2.23
A/ Short Cut Formula

Design: 4 x 4 Triple Lattice - 9 reps.
Plot Size: 2 rows (30") x 53' Planted
2 rows x 50' Harvested
Planted: October 7, 1960
Harvested: August 14-16, 1961

1/ Not available in time for report.

Above results extracted from a test of 16 varieties

Variety Test 1961 Ryer Island

Coop: Jongeneel & Hechtman

Variety	Source	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P. 1/	No. Beets 100' Row
USH2	L9381	5583	25.059	11.14		159
USH4	L0336	5099	22.405	11.38		162
US75	L9252	4547	20.374	11.16		163
Gen. Mean		4593	20.454	11.31		158
SE mean		269A/	1.063	.31		
LSD (5%)		750	2.964	.86		
SEm/Gen. Mean (%)		5.86	5.20	2.72		

Variance Table

Variation Due To	DF	Mean Squares Tons Beets	Mean Squares % Sucrose	Mean Squares % T.J.P.
Replication	8	100.588	7.076	
Variety	29	189.151	3.557	
Error	232	10.167	.852	
Total	269			
Calc. F.		18.60**	4.18**	

** Exceeds 1% point 1.79

A/ Short Cut Formula

Design: 5 x 6 Rectangular Lattice - 9 reps.
Plot Size: 2 rows (28") x 53' Planted
2 rows x 50' Harvested
Planted: February 2, 27 & 28, 1961
Harvested: September 11, 12, 13, 1961

1/ Not available in time for report.

Above results were extracted from a test of 30 varieties

Variety Test 1961 Staten Island

Coop: M & T, Inc.

Variety	Source	Gross Sugar	Tons Per Acre	% Sucrose	% 1/ T.J.P.	No. Beets 100' Row
USH2	L9381	8709	30.862	14.11		148
USH4	L0336	8414	28.737	14.64		153
USH6	L0389 (NB1xNB5) x C663	8347	29.959	13.93		151
US75	L9252	7532	27.192	13.85		164
Gen. Mean		8386	29.333	14.32		153
SE mean		382A/	1.244	.24		
LSD (5%)		1066	3.469	.67		
SEm/Gen. Mean (%)		3.79	4.24	1.68		

Variance Table

Variation Due To	DF	Mean Squares Tons Beets	Mean Squares % Sucrose	Mean Squares % T.J.P.
Replication	8	89.753	17.070	
Variety	29	49.137	4.440	
Error	232	13.927	.518	
Total	269			
Calc. F		3.53**	8.57**	

** Exceeds 1% point 1.79
A/ Short Cut Formula

Design: 5 x 6 Rectangular Lattice - 9 reps.
Plot Size: 2 rows (20") x 53' Planted
2 rows x 50' Harvested
Planted: April 17, 1961
Harvested: November 14-18, 1961

1/ Not available in time for report.

Above results extracted from a test of 30 varieties

Variety Test 1961 Hamilton City

Coop: Geo. Stutz

Variety	Source	Gross Sugar	Tons Per Acre	% Sucrose	LSR 1/ Index	% 2/ T.J.P.	No. Beets 100' Row
USH2	L9381	6949	23.383	14.86	3.4		158
USH6	L0389 (NB1MS x NB5) x C663	6560	22.360	14.67	3.0		170
USH4	L0336	6122	20.681	14.80	3.2		166
US75	L9252	5819	20.233	14.38	3.0		174
Gen. Mean		6280	21.626	14.52			171
SE mean		218 A/	.716	.15			
LSD (5%)		609	1.996	.43			
SEm/Gen. Mean (%)		3.48	3.31	1.06			

Variance Table

Variation Due To	DF	Mean Squares: Tons Beets	Mean Squares: % Sucrose	Mean Squares: % T.J.P.
Replication	8	173.053	6.682	
Variety	29	45.812	1.051	
Error	232	4.608	.213	
Total	269			
Calc. F		9.94**	4.93**	

** Exceeds 1% point 1.79
A/ Short Cut Formula
1/ 1-10 1-resistant 10-susceptible
Design: 5 x 6 Rectangular Lattice - 9 reps.
Plot Size: 2 rows (30") x 53' Planted
2 rows x 50' Harvested
Planted: April 4, 1961
Harvested: October 19, 20, 21 - 1961

2/ Not available in time for report.

Above results extracted from a test of 30 varieties

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1961

Test Areas:	SPRECKELS				SPRECKELS				SPRECKELS				SPRECKELS			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
C9921H1	4.683	32.79	14.3	106					2.488	18.45	13.5	116				
C9921H2	4.593	30.84	14.9	117					2.592	19.26	13.5	112				
C9921H3	4.235	29.66	14.3	118					2.430	17.70	13.7	116				
0539H1					4.856	31.89	15.2	123								
0539H2					4.530	29.02	15.6	123								
0562H2					4.431	29.81	14.8	115								
087H1					4.286	28.58	15.1	120								
086H3					4.276	27.59	15.5	124								
0546-36H2					4.134	27.61	14.9	108								
887H5					4.091	27.21	15.1	124								
086H1					4.036	26.38	15.3	122								
886H5					4.003	27.12	14.8	117								
US 75					3.874	26.22	14.7	122								
US56/2					3.621	24.79	14.7	119								
063H6													4.450	31.31	14.2	123
063H8													4.183	29.25	14.4	127
063H2													4.504	31.26	14.5	117
F59-63H4													4.168	28.10	14.9	123
063H7													4.155	28.74	14.5	123
063H1													4.108	28.48	14.5	128
063H3													3.899	26.99	14.4	116
063H9													3.894	27.72	14.1	123
Planting Date		January 5, 1961				December 13, 1960				February 28, 1961				December 13, 1960		
Harvest Date		August 25, 1961				August 24, 1961				September 13, 1961				August 23, 1961		
General Mean	4.350	30.40	14.3	113	4.247	28.17	15.1	121	2.659	20.26	13.1	126	3.969	27.51	14.3	120
LSD @ P - .05	.396	2.61	.58		.611	NS	.58		.347	2.26	.69		.570	3.73	.67	
LSD @ P - .01	.526	3.47	.77		NS	NS	NS		.461	2.99	.92		NS	NS	NS	
S E of Mean	.139	.924	.204		.217	.428	.207		.123	.799	.244		.203	1.325	.232	
S E % of Mean	3.195	3.039	1.427		5.109	1.519	1.371		4.626	3.944	1.863		5.115	4.816	1.622	
# Var. in Test		ten				twelve				fifteen				fourteen		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1961

Test Areas:	KING CITY				SAN JUAN				MISSION - SOLEDAD				GILROY			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
063H1	4.931	35.57	13.9	135												
US 56/2	3.912	27.29	14.3	143												
063H2					4.715	30.09	15.7	155	4.919	29.90	16.5	142	4.741	32.39	14.6	147
063H3					4.620	29.76	15.5	157								
887H5					4.384	27.67	15.8	149								
F59-63H4					4.335	28.49	15.1	170					4.880	34.09	14.3	150
US 75					3.821	25.73	14.9	170	4.003	25.18	15.9	149	4.161	28.67	14.5	145
PLANTING DATE:		February 10, 1961				December 23, 1960				December 20, 1960				December 13, 1960		
Harvest Date:						August 30, 1961				September 19, 1961				August 23, 1961		
General Mean	4.604	32.66	14.1	139	4.171	27.61	15.1	160	4.284	26.90	15.9	142	4.489	31.25	14.4	144
LSD @ P - .05	.424	2.55	.86		.497	2.92	.72		.448	2.73	.69		.456	2.98	NS	
LSD @ P - .01	.563	3.39	NS		.661	3.88	.95		.598	3.64	.87		.606	3.96	NS	
S E of Mean	.149	.902	.305		.175	1.034	.253		.157	.960	.229		.161	1.054	.146	
S E % of Mean	3.236	2.762	2.163		4.196	3.745	1.675		3.665	3.569	1.440		3.587	3.373	1.014	
# of Var. in Test		ten				ten				eight				ten		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1961

Test Areas:	KERN LAKE				FIVE POINTS				FIVE POINTS				CORCORAN			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
0539H1	4.101	31.06	13.21													
063H3	3.858	28.86	12.76													
063H1	3.770	28.41	13.26						2.839	21.46	13.23	117				
59-63H4	3.501	26.40	13.60		1.148	10.19	11.27	119								
886H5	3.283	25.32	12.67													
US 75	2.915	22.52	13.00		1.090	9.75	11.14	97	1.983	15.63	12.67	113	1.352	9.10	14.90	157
063H2					1.269	11.15	11.32	88	2.693	20.71	12.98	115				
5963H1													1.379	8.85	15.6	137
Planting Date	January 5, 1961				December 30, 1960				October 24, 1960				September 16, 1960			
Harvest Date	July 14, 1961				July 28, 1961				July 27, 1961				July 4, 1961			
General Mean	3.597	26.80	13.3		1.182	10.47	11.24	97	2.389	18.66	12.8	111	1.455	9.62	15.13	141
LSD @ P - .05	.464	2.93	.56		.220	1.78	.39		.250	1.888	.46		.217	1.48	.37	
LSD @ P - .01	.616	3.89	.74		.292	2.36	.52		.332	2.51	.61		.289	1.98	.49	
S E of Mean	.165	1.040	.199		.078	.604	.138		.088	.668	.163		.076	.522	.125	
S E % of Mean	4.587	3.881	1.496		6.599	5.769	1.228		3.684	3.580	1.273		5.223	5.426	.826	
# of Var/Test	sixteen				eight				eight				eight			

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1961

Test Areas:	ORA LOMA				FIVE POINTS				FIVE POINTS				FIVE POINTS			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
0562H2	2.708	17.68	15.26		2.795	18.80	14.93	157	2.592	22.93	11.31	169				
063H1	2.648	18.41	14.48													
US 75	2.496	17.76	14.36		1.910	13.36	14.26	155	2.040	18.39	11.09	172				
087H1	2.275	15.26	14.93													
063H3	2.113	14.69	14.35													
5963H1					2.346	16.24	14.45	146								
063H2 (Thimet)													1.008	9.02	11.30	157
063H2 (Check)													0.732	6.28	11.72	156
US 75 (Thimet)													0.910	8.04	11.34	161
US 75 (Check)													0.732	6.28	11.72	156
Planting Date	January 16, 1961				September 24, 1960				September 29, 1960				March 7, 1961			
Harvest Date	September 27, 1961				July 27, 1961				June 30, 1961				July 27, 1961			
General Mean	2.349	15.97	14.71		2.237	15.60	14.3	148	2.306	20.69	10.1	167	.964	8.29	11.50	147
LSD @ P - .05	.506	2.77	.68		.278	1.84	.65		.392	3.01	.99		.178	1.61	.45	
LSD @ P - .01	.671	3.68	.90		.369	2.44	.87		.523	4.01	1.33		.236	2.14	.59	
S E of Mean	.180	.984	.240		.099	.649	.231		.195	1.058	.497		.063	.569	.158	
S E % of Mean	7.663	6.162	1.632		4.426	4.160	1.615		8.456	5.114	4.921		6.535	6.864	1.374	
# Var./Test	Sixteen				eight				ten				sixteen			

VARIETY TEST, KING CITY, CALIFORNIA, 1961

Grower and location: A. S. Duarte, King City, California.

Soil type: Salinas clay.

Previous crops: Sugarbeets, 1957; peas and lettuce, 1958; carrots, 1959; tomatoes, 1960.

Fertilizer used: 420 lbs. per acre 12:15:0, preplant.
400 lbs. per acre 20:0:0, first sidedress.
480 lbs. per acre 20:0:0, second sidedress.

Planting date: February 16, 1961.

Thinning date: March 25, 1961.

Harvest date: October 11-12, 1961.

Irrigations: Six.

Diseases and insects: A light to severe infection with curly top caused severe damage in susceptible varieties and light damage in resistant varieties. Infection with yellows viruses was generally moderate throughout test area. Fairly heavy infestation of leaf miner occurred in mid-season. Light damage to foliage occurred. Nematode infestation was light in the plot area.

Experimental design: Randomized block with eight replications; only six replications harvested. Randomized block with four replications, all harvested;and randomized block with four replications, only three replications harvested. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed was furnished, test designed,and results analyzed by the United States Agricultural Research Station, Salinas, California. A moisture problem after planting resulted in spotty stands throughout the test plot area and forced abandonment of a total of three replications of the test.

VARIETY TEST, KING CITY, CALIFORNIA, 1961

(6 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
063H1	US H2	11,227	33.7	16.7	139
063H2	US H6	11,147	32.9	17.0	143
F59-63H4	(MS of 7515 x 7569) x 663	10,833	32.3	16.8	129
063H9	(MS of 8569 x 8507) x 663	10,820	31.9	17.0	140
063H3	US H5B	10,666	32.2	16.6	139
0539H1	(MS of 7515 x 7569) x 8539	10,657	32.5	16.4	124
063H8	(MS of 7515 x 8507) x 663	10,520	32.3	16.3	140
086H3	US H5A	10,081	29.4	17.2	136
0562H2	F58-85H0 x 0562	9,982	31.3	16.4	124
F57-68	US 75	9,975	31.0	16.1	144
F60-561H2	F58-85H0 x 9561-4	9,751	28.9	16.9	126
9921H3	(MS of 7515 x 7569) x H3611	8,040	23.9	16.9	119
General MEAN of all varieties		10,308	31.0	16.7	Beets per 100' row
S. E. of MEAN		394	1.19	0.23	
Significant Difference (19:1)		1,117	3.37	0.65	
S. E. of MEAN in % of MEAN		3.82	3.84	1.38	

Odds 19:1 = 2.004 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	11	4,420,185	41.8	0.64
Between replications	5	2,889,282	27.2	2.02
Remainder (Error)	55	932,709	8.5	0.32
Total	71			
Calculated F value		4.74**	4.93**	2.00*

* Exceeds the 5% point of significance (F=1.97)
** Exceeds the 1% point of significance (F=2.59)

VARIETY TEST, KING CITY, CALIFORNIA, 1961

(4 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
063H1	US H2	11,021	33.7	16.4	149
0539H1	(MS of 7515 x 7569) x 8539	10,255	32.6	15.8	127
E-67	TASCO mm Hybrid	9,782	28.4	17.3	140
9953-1	(MS of 7515 x 7569) x D10	8,821	26.2	16.9	96
F57-68	US 75	8,714	28.0	15.7	129
9921H1	(MS of NB1 x NB3) x H3611	8,641	25.2	17.2	116
9952-7	(MS of NB1 x NB4) x E33	8,607	27.2	15.8	102
086H1	US H3	8,580	25.6	16.7	127
9953-7	(MS of 7515 x 7569) x E33	8,559	25.8	16.8	101
9952-8	(MS of NB1 x NB4) x F13	8,494	25.9	16.4	110
9953-3	(MS of 7515 x 7569) x D18	8,037	24.1	16.8	82
Polybeta	German Polyploid	6,286	18.2	17.4	93
General MEAN of all varieties		8,816	26.7	16.6	Beets
S. E. of MEAN		524	2.29	0.44	per
Significant Difference (19:1)		1,503	6.57	N.S.	100'
S. E. of MEAN in % of MEAN		5.94	8.57	2.65	row

Odds 19:1 = 2.03 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	11	5,522,622	62.51	1.37
Between replications	3	18,418,787	204.63	1.38
Remainder (Error)	33	1,096,601	9.14	0.77
Total	47			
Calculated F value		5.04**	6.84**	N.S.

** Exceeds the 5% point of significance (F=2.09)

VARIETY TEST, KING CITY, CALIFORNIA, 1961

(3 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
0539H2	(MS of 7515 x 9561) x 8539	9,785	30.7	15.9	135
0546-22H1	F58-85HO x 8546-22	9,601	30.9	15.5	96
0546-48H1	F58-85HO x 8546-48	9,406	30.8	15.2	111
0583-28H1	F58-85HO x 8583-28	9,250	28.6	16.2	109
0546-11H1	F58-85HO x 8546-11	9,035	28.1	16.1	107
0583-34H1	F58-85HO x 8583-34	9,029	28.1	16.1	103
011	V. Yel. sel. from US 75	8,907	28.1	15.9	102
0546-8H2	F58-85HO x 8546-8	8,895	29.9	14.9	114
0583-30H1	F58-85HO x 8583-30	8,770	26.9	16.4	97
0583-44H1	F58-85HO x 8583-44	8,763	27.7	15.8	114
0546-36H2	F58-85HO x 8546-36	8,518	29.1	14.7	121
F57-68	US 75	7,888	25.3	15.6	133

	Sugar	Beets	Sucrose	
General MEAN of all varieties	8,987	28.7	15.7	Beets per 100' row
S. E. of MEAN	728	2.26	0.15	
Significant Difference (19:1)	N.S.	N.S.	0.44	
S. E. of MEAN in % of MEAN	8.09	7.88	0.96	

Odds 19:1 = 2.07 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Between varieties	11	764,510	8.88	0.89
Between replications	2	2,033,717	44.33	1.71
Remainder (Error)	22	1,649,884	15.31	0.36
Total	35			
Calculated F value		N.S.	N.S.	2.47*

* Exceeds the 5% point of significance (F=2.26)

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1961

Grower and location: Pezzoni and Silva, Pezzoni Ranch, Guadalupe, California.

Soil type: Yolo sandy loam.

Previous crops: Alfalfa, 1957; carrots, 1958; cauliflower and lettuce, 1959; lettuce and cauliflower, 1960.

Fertilizer used: No preplant used.
Sidedressed 700 lbs. per acre ammonium sulfate March 20, 1961. Sidedressed 600 lbs. per acre ammonium sulfate April 25, 1961.

Planting date: January 10, 1961.

Thinning date: March 1, 1961.

Harvest date: October 4, 1961.

Irrigations: Five.

Diseases and insects: Infection with yellows viruses was generally light. Other diseases were not a factor in the test plot. A light infestation of leaf miner occurred in the field but caused no significant damage. Nematode infestation was fairly light in the test plot.

Experimental design: Randomized block with eight replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples by Union Sugar Division, Betteravia, California.

Remarks: Seed was furnished, test designed, and results analyzed by United States Agricultural Research Station, Salinas, California.

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1961

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	T. J. Purity Percent	Harvest Count Number
063H3	US H5B	12,000	35.3	17.0	92.3	165
063H2	US H6	11,689	35.2	16.7	92.5	156
0562H2	F58-85H0 x 0562	11,094	33.0	16.8	92.9	153
0539H1	(MS of 7515 x 7569) x 8539	11,011	33.0	16.7	92.7	159
F59-63H4	(MS of 7515 x 7569) x 663	10,991	32.7	16.8	93.3	165
086H3	US H5A	10,911	31.9	17.1	92.9	165
063H9	(MS of 8569 x 8507) x 663	10,820	32.5	16.7	92.5	161
F57-68	US 75	10,247	31.4	16.5	91.5	154
087H1	(MS of NB5 x NB6) x F58-87	10,159	31.9	15.9	90.8	157
F60-561H2	F58-85H0 x 9561-4	9,674	29.1	16.6	92.8	151
General MEAN of all varieties		10,860	32.6	16.7	92.4	Beets
S. E. of MEAN		257	0.71	0.13	0.45	per
Significant Difference (19:1)		727	2.01	0.36	1.28	100'
S. E. of MEAN in % of MEAN		2.37	2.18	0.75	0.51	row

Odds 19:1 = 2.00 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose	Percent T.J.P.
Between varieties	9	3,875,576	25.85	0.87	4.34
Between replications	7	716,516	11.74	0.73	1.58
Remainder (Error)	63	527,682	4.04	0.13	1.63
Total	79				
Calculated F value		7.34**	6.40**	6.69**	2.66*

* Exceeds the 5% point of significance (F=2.02)
** Exceeds the 1% point of significance (F=2.63)

DEVELOPMENT OF TRIPLOID AND TETRAPLOID SUGAR BEETS

B. L. Hammond

Continued emphasis has been placed during the past year on the production of polyploid strains of sugar beets to determine their value for the West Coast area.

In last year's report it was stated that a portion of seed obtained from the C_0 generation of colchicine-treated seed of the multigerm topcross parent, 663, was planted in Oregon in July 1960 to produce stecklings for seed increase at Salinas. In March 1961, 153 stecklings were isolated in San Miguel Canyon near Salinas. A cytological examination indicated that 131, or 86 percent, of these plants were tetraploid. Approximately 5 pounds of seed was harvested in July from the tetraploid plants. In August, a portion of this seed was made available to the Foundation as variety 163T for evaluation and seed increase.

Sixty-five plants also identified as tetraploids were isolated in the Alisal area along with the male-sterile monogerm diploid, MS of 7515 X 7569, and the male-sterile multigerm diploid, MS of NB1 X NB3, for the production of triploid seed. These triploid hybrids will be evaluated in 1962 in USDA and cooperative sugar company variety tests.

Also isolated were 13 tetraploid plants of 663 origin having green hypocotyls, from which a small quantity of seed was obtained. A seed increase of this selection is being made.

Seed of 46 selected colchicine-treated plants of the multigerm inbred, 0539, was harvested in April 1961 and some immediately planted, from which 125 seedlings were obtained. Ninety-six percent of the plants of the C_1 generation were tetraploids. These were placed under thermal induction in August together with a group of plants of the self-sterile tetraploid of 663 origin described above. These two tetraploids from high performing diploids will be crossed to produce tetraploid pollinators. Another portion of the C_1 generation seed from colchicine-treated 0539 was planted in Oregon in August to obtain stecklings for seed increase at Salinas next spring.

Seed of progenies of 53 T8-line single-plant tetraploid selections was collected during the year. Seed increases are being made of a number of the selections. The T8 line is a group of tetraploid plants produced from S_6(US 22/3 X NB1).

The type O monogerm inbred, 0562, and its male-sterile equivalent, 9561H2, were chosen for the development of a male-sterile monogerm tetraploid line. Colchicine treatment was begun in September 1960. In December 1960, 50 plants of the former and 66 of the latter were selected as being highly tetraploid chimeras on the basis of chromosome observations in vegetative tissue and exposed to thermal induction for 120 days. At the end of this period, 33 plants of the former and 47 of

the latter had survived. Just prior to flowering, young tissue from the tip of the floral axis of each was examined cytologically. Twenty-four of the former and 42 of the latter were selected for pollination on the basis of the apparent absence of diploid cells. Fertility was very low. However, a small quantity of seed was obtained, a portion of which was planted in September 1961. From the cross between colchicine-treated 0562 and its male-sterile equivalent, 9561H2, 121 seedlings, all tetraploid, were obtained. From 0562 selfed, 63 plants were obtained, all also tetraploid. These plants are nearly ready for thermal induction, and a seed increase will be made.

A procedure similar to that above is being used in connection with the diploid monogerm lines SL0156 (MSmm X CT5mm) and SL0267 (SLC129mmaa X CT5mmAa), both developed by Dr. Owen. Treatment was begun in November 1960, and seed from the C_o generation is now ready for harvesting. These lines will be carried through another generation at this Station.

Seventy-four colchicine-treated plants of the monogerm inbred 0546-36 were selected in July and placed under thermal induction. These have been moved to the greenhouse for cytological examination and pollination.

Germinating seed of the monogerm inbred 0546-48 was colchicine-treated in June. Seventy-two plants selected of the basis of cytological examination are now undergoing a 4 month's period of thermal induction.

Fifty-seven colchicine-treated plants grown from seed of the monogerm inbred 0546-22 were selected and placed in the coldroom in November 1961.

One-hundred thirty-eight colchicine-treated seedlings of the monogerm inbred 1546-22 were transplanted to pots in October 1961. Forty-nine of these have been selected for thermal induction. Selection 1546-22 differs from 0546-22 in being more resistant to curly top.

Tetraploids are also being produced in the monogerm inbred 1672 which originated from a backcross to the NB1 multigerm inbred. One-hundred seventy plants grown from colchicine-treated seed soon will be examined cytologically, selected and placed under thermal induction.

Sixty-six colchicine-treated plants of the type O multigerm 871 were selected and placed under thermal induction in July 1961. These are now in the greenhouse and soon will be ready for cytological examination, selection and increasing. The 14 plants having green hypocotyls will be segregated for separate pollination.

Colchicine-treated seed of the type O multigerm, F57-85, and its male-sterile equivalent, F57-85HO, is now being grown in the greenhouse for selection of tetraploid material.

GREENHOUSE CHAMBERS FOR SMALL SEED INCREASES

J. S. McFarlane and I. O. Skoyen

The sugarbeet breeder must frequently make small seed increases of breeding lines and hybrid combinations. These increases can be made in field isolations, but costs are high and great care is required to avoid contamination from outside pollen. Greenhouse chambers ventilated with filtered air are widely used in Europe for producing small quantities of seed. The Great Western Sugar Company has developed a compartmented greenhouse at Longmont, Colorado which uses the principle of negative pressure for ventilating and cooling.[1] Following a study of these facilities a group of 12 compartments was constructed at the U. S. Agricultural Research Station, Salinas, California in 1961.

A prefabricated, aluminum-framed greenhouse without doors or roof vents was used as the basic unit (Figure 1). The greenhouse measured 32 feet x 9 feet and was divided into 6 sections using standard commercial partitions. Each section was subdivided into 2 equal-sized chambers by cross partitions constructed of vinyl-plastic film. The planting area within the chambers measured 57 inches x 50 inches. All seams and joints between chambers were sealed with either a caulking compound or plastic cement. Entry to each compartment was gained through modified, commercial ventilating sash hinged at the eave line (Figure 1).

Filtered air was provided from a fan house constructed at the head of the greenhouse. The fan was located in a pollen-tight room and air was drawn through filters fitted with a cotton media capable of removing air contaminants below the size of sugarbeet pollen (Figure 2). The filtered air was directed through an underground duct constructed of concrete pipe and parallel to the greenhouse. Junction boxes were placed at 15-foot intervals in the concrete pipe and 4-inch transite pipe was used to carry the filtered air from the junction boxes to the individual chambers. The air flow was adjusted to provide a change of air every 2 minutes or less. Air escaped through flutter valves located in the outside wall of each chamber.

Thermally induced beet roots were planted in beds which were formed by placing soil to a depth of one foot inside the chamber foundations. The plants were furrow irrigated and the flow of water was controlled by valves located just outside the chambers. Supplementary light was furnished from a 150-watt incandescent bulb in each chamber and controlled by a time clock. Fumigants for insect control were introduced through the air outlets.

---

[1] Wood, R. R., Conwell, D. E., Impey, C. Walters, and Smith, P. B. 1960. Development of air conditioned, compartmented greenhouse. Jour. Amer. Soc. Sugar Beet Tech. XI (1): 44-48.

The plants grew vigorously and flowered normally in the chambers. Some difficulty was experienced with pollen distribution and provisions for shaking the plants during pollination would be desirable. Seed yields as high as 2 3/4 pounds per chamber were obtained. Very little contamination occurred with pollen from the outside. This was determined by planting one chamber entirely to male-sterile plants and counting the seeds which were formed at the end of the pollinating season. Only 17 seeds were identified [redacted] having arisen from fertilization with outside pollen.

Two crops of seed were grown in each chamber in 1961. Three seed crops per year should be possible by carefully coordinating the supply of thermally induced roots with the dates the chambers are available for planting.

Figure 1. Compartmented greenhouse used for production of sugarbeet seed at Salinas, California. Filtered air from fan house (top, right) is supplied to each chamber through underground ducts.

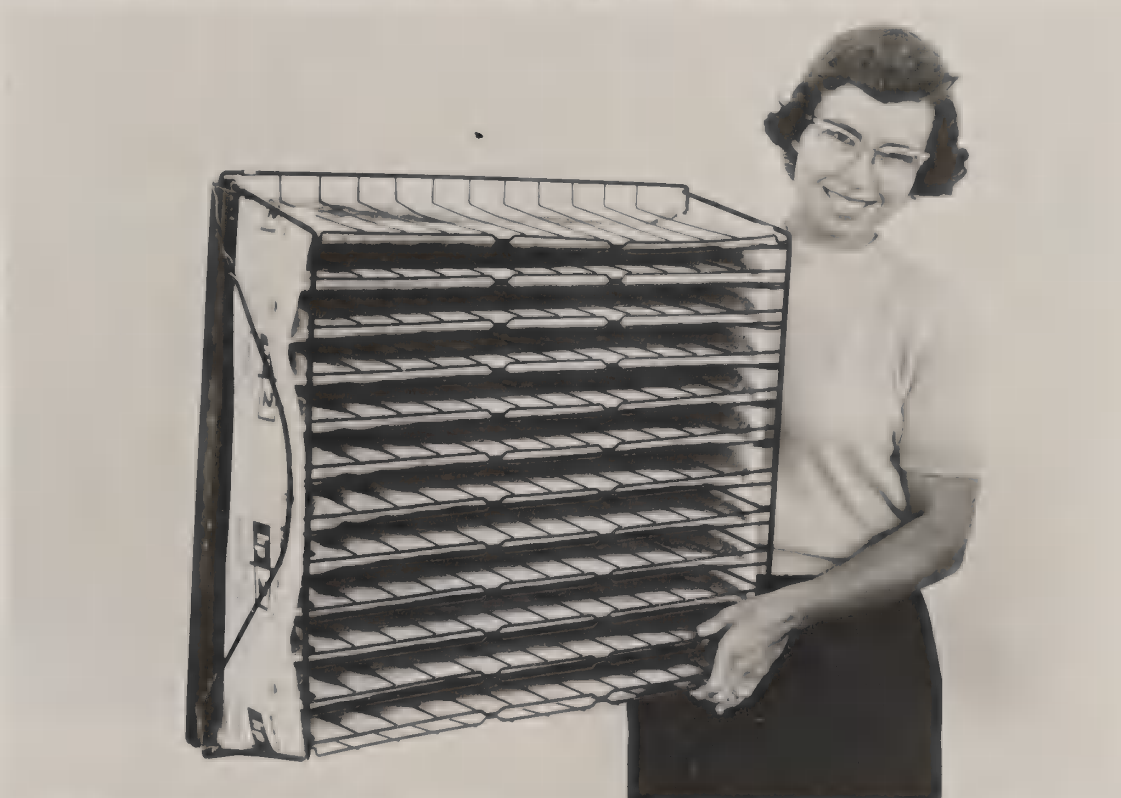


Figure 2. Filter unit consisting of a replaceable, pleated-cotton, filter cartridge and a metal retainer.

PART III

DEVELOPMENT AND EVALUATION OF INBRED LINES AND HYBRID VARIETIES OF SUGARBEETS

with emphasis on

Curly Top Resistance
Monogermness and High Quality

Foundation Projects 22 and 23

F. V. Owen
A. M. Murphy
K. D. Beatty
G. K. Ryser
C. H. Smith
Myron Stout
J. C. Overpeck

Cooperators conducting field tests:

New Mexico Agricultural Experiment Station
Southwestern Irrigation Field Station, Brawley, California
Utah-Idaho Sugar Company
The Amalgamated Sugar Company

SALT LAKE CITY STATION BECOMES A MEMORY

The staff of Sugar Beet Investigations was officially transferred from 1810 South Main Street, Salt Lake City, Utah, to Crops Research Laboratory, Utah State University, Logan, on July 1, 1961. The Salt Lake City location had served as headquarters for regional sugarbeet research for more than 30 years.

A brief description and a photograph of the architectural rendering of the new facilities are given on pages 66 and 67, respectively.

Mr. Albert M. Murphy, Research Agronomist, and Mr. B. J. Ruffing, Agricultural Aid, were transferred from Twin Falls, Idaho, to the Crops Research Laboratory, Logan, Utah, January 1, 1962. For several years, sugarbeet research at Twin Falls was conducted in close cooperation with the staff at Salt Lake City. The transfer will permit further consolidation of research activities on regional problems.

Drs. V. F. and Helen Savitsky, who were employed in 1947 by the Beet Sugar Development Foundation and worked as Collaborators at the Salt Lake City Station, were transferred in March 1961 to the Agricultural Research Field Station, Salinas, California. They are now geneticists under Civil Service appointment and remain as members of the staff of Sugar Beet Investigations. They will continue basic research on genetics, cytology, and interspecific hybrids at their new location.

The nostalgia for the "Old Station" is a problem yet to be resolved by those who have made the transfer.

CROPS RESEARCH LABORATORY
LOGAN, UTAH

A photograph of the architectural rendering of the Crops Research Laboratory is shown on the opposite page. It is a good representation of the finished structures and the scenic environs.

The first floor, except for the front offices used by ARS Administrative Assistants and the portion used as headhouse, is occupied by the staff of Sugar Beet Investigations. There are offices and laboratories for sugarbeet research in agronomy, genetics, cytology, biometry, plant pathology, and plant physiology.

The basement provides space for refrigerated storage of roots, for processing root samples, and laboratory for sugar analyses. In addition there are laboratories for physiological and chemical research, as well as space for plant growth chambers.

The second floor of the building is occupied by staff members of Forage and Range Research Branch; Safflower Investigations, Oilseed and Industrial Crops Research Branch; and Nematology Investigations, Crops Protection Research Branch.

The greenhouse shown in the photograph is assigned to sugarbeet research. A similar greenhouse at the other end of the building is used by investigators occupying the second floor of the laboratory.

The service building for storage of trucks and other equipment is shown to the right of the greenhouses.

CROPS RESEARCH LABORATORY LOGAN, UTAH

EIGHT HYBRIDS AT FOUR LOCATIONS, 1961 TESTS[1/]

8 Replications at each location

VARIETY	DESCRIPTION	LOGAN, UTAH ACRE YIELD GROSS SUGAR	LOGAN TONS BEETS	LOGAN SUGAR PERCENT	LEWISTON, UTAH ACRE YIELD GROSS SUGAR	LEWISTON TONS BEETS	LEWISTON SUGAR PERCENT	KIMBERLY, IDAHO ACRE YIELD GROSS SUGAR	KIMBERLY TONS BEETS	KIMBERLY SUGAR PERCENT	JEROME, IDAHO ACRE YIELD GROSS SUGAR	JEROME TONS BEETS	JEROME SUGAR PERCENT
9140	7121 MS mm X CT5B	7,236	26.4	13.7	8,994	33.8	13.3	9,670	32.7	14.8	11,388	33.5	17.0
9122A	7121 MS mm X CT5A	7,068	26.3	13.4	8,493	33.2	12.8	10,121	34.0	14.9	10,581	32.0	16.6
0457	630 aa X CT5	7,036	25.1	14.0	7,994	30.0	13.4	10,370	33.1	15.7	10,958	32.4	16.9
0110	211H3 X CT5 mm	6,916	25.3	13.7	8,065	30.4	13.3	10,259	34.4	14.9	10,592	32.0	16.6
0539H1[2/]	7515 MS mm X 7569	6,626	25.3	13.0	8,052	33.5	12.1	9,160	32.7	14.0	9,976	30.2	16.5
0462	CT8 aa X Line 289	6,471	20.8	15.6	7,544	25.1	15.0	8,236	24.0	17.2	8,648	23.4	18.5
E 67[3/]	CT9 MS X mm	6,390	23.1	13.7	8,720	32.2	13.6	9,848	31.9	15.4	10,605	31.4	16.9
0179	MS mm X CT5 mm	6,375	23.6	13.5	8,337	30.3	13.8	9,098	30.0	15.2	9,689	28.7	16.9
General MEAN of all varieties		6,765	24.48	13.82	8,275	31.1	13.4	9,595	31.6	15.24	10,305	30.4	17.0
Sig. Diff. (19:1)		526	1.82	0.57	651	1.91	0.68	789	2.40	0.51	695	2.18	0.45

1/ Sugar analyses for all Idaho tests were made by the Amalgamated Sugar Company

2/ Hybrid 0539H1 was produced by Dr. J. S. McFarlane

3/ Hybrid E 67 (CT9 multi. MS X mm) was produced by the Amalgamated Sugar Company

VARIETY TEST, LOGAN, UTAH, 1961

By G. K. Ryser and
C. H. Smith

GROWER: Parley L. Bodrero

SOIL TYPE: Ricks silty clay loam

PREVIOUS CROPS: Alfalfa, 7 years; 1959, grain; 1960, fallow; 1961, sugar beets.

FERTILIZERS: 400 lbs. of ammoniated phosphate (20-40) per acre applied in the fall of 1960 previous to fall plowing.

PLANTED: April 11, 1961

THINNED: May 22, 1961

IRRIGATIONS: First irrigation, July 1. Four irrigations by furrow. Irrigations 18 days apart.

CURLY TOP: Marked symptoms were noted in susceptible varieties but rare in resistant varieties.

HARVESTED: October 16, 1961. At harvest the tops were removed with a roto-beater and the beets scalped with tractor-mounted scalping tools supplemented by long-handled hoe work. Beets were counted as they were being elevated to the weighing basket. Both rows were weighed and sampled for sugar analyses. These samples were weighed after washing to determine tare percentages.

EXPERIMENTAL DESIGN: Test I was planted in an 8 X 8 Latin square. Test II was planted in a 5 X 6 rectangular lattice with 6 replications. Test III was planted in randomized block design. The beets were planted in 2-row plots with 22 inches between rows. Objective at thinning was 8 to 10 inches. Four-foot alleys were cut between plots. Effective plot length was 45 feet.

VARIETY TEST, LOGAN, UTAH, 1961

8 replications of each variety

TEST I

VARIETY	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 190' ROW
(F) 9140	7121 MS mm X CT5B	7,236	26.4	13.7	81.6	6700	640	2650	103
(H) 9122A	7121 MS X CT5A	7,068	26.3	13.4	81.0	7400	660	2600	102
(E) 0457	630 aa X 94.35 of CT5	7,036	25.1	14.0	82.2	7400	600	2460	100
(D) 0110	211H3 X CT5 mm	6,916	25.3	13.7	80.8	7500	610	2580	103
(A) 0539H1[1]	7515 MS mm X 7569	6,626	25.3	13.0	79.9	6400	880	2840	92
(C) 0462	CT8 aa X Line 289	6,471	20.8	15.6	83.0	7400	290	2180	97
(B) E 67[2]	CT9 MS X mm	6,390	23.1	13.7	80.9	6800	670	2710	91
(G) MS mm X CT5		6,375	23.6	13.5	81.0	6700	560	2680	99
General MEAN of all varieties		6,765	24.48	13.82	81.30	7031	612	2587	
S. E. of MEAN		184	0.64	0.20	NS	NS	32.59	94.67	
Sig. Diff. (19:1)		526	1.82	0.57			93.00	270.50	
S. E. of MEAN in % of MEAN		2.72	2.61	1.45			5.33	3.66	
Cal. F. Values		3.42**	8.90*	4.85**			24.71	4.47	

1/ Hybrid 0539H1 was produced by Dr. J. S. McFarlane

2/ Hybrid E 67 (CT9 multi. MS X mm) was produced by the Amalgamated Sugar Company

VARIETY TEST, LEWISTON, UTAH, 1961

In cooperation with the Amalgamated Sugar Company

8 X 8 Latin Square

TEST I

Planted April 10, 1961
Harvested October 6, 1961

VARIETY	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	SUGAR PERCENT	BEETS 100' ROW
9140	7121 MS mm X CT5B	8,994	33.8	13.3	126
E 67[1/]	CT9 MS X mm	8,720	32.2	13.6	115
9122A	7121 MS X CT5A	8,493	33.2	12.8	120
0179	MS mm X CT5 mm	8,337	30.3	13.8	115
0539H1[2/]	7515 MS mm X 7569	8,052	33.5	12.1	118
0110	211H3 X CT5 mm	8,065	30.4	13.3	120
0457	630 aa X CT5	7,994	30.0	13.4	112
0462	CT8 aa X Line 289	7,544	25.1	15.0	115
General MEAN of all varieties		8,275	31.1	13.4	118
S. E. of MEAN		228	0.67	0.24	
Sig. Diff (19:1)		651	1.91	0.68	
S. E. of MEAN in % of MEAN		2.76	1.61	1.79	
Cal. F. Values		4.04**	18.24**	12.98**	

1/ Hybrid E 67 was produced by the Amalgamated Sugar Company

2/ Hybrid 0539H1 was produced by Dr. J. S. McFarlane

VARIETY TEST, KIMBERLY, IDAHO, 1961

In cooperation with the Amalgamated Sugar Company

8 X 8 Latin Square — TEST I

Planted April 7, 1961
Harvested October 13, 1961

VARIETY	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	SUGAR PERCENT	BEETS 100' ROW
0457	630 aa X CT5	10,370	33.1	15.7	111
0110	211H3 X CT5 [redacted]	10,259	34.4	14.9	115
9122A	7121 MS [redacted] X CT5A	10,121	34.0	14.9	110
E 67[1/]	CT9 MS mm X mm	9,848	31.9	15.4	107
9140	7121 MS mm X CT5B	9,670	32.7	14.8	101
0179	MS mm X CT5 mm	9,098	30.0	15.2	112
0539H1[2/]	7515 MS mm X 7569	9,160	32.7	14.0	112
0462	CT8 aa X Line 289	8,236	24.0	17.2	101
General MEAN of all varieties		9,595	31.6	15.24	109
S. E. of MEAN		275	0.84	0.18	
Sig. Diff (19:1)		789	2.40	0.51	
S. E. of MEAN in % of MEAN		2.87	2.66	1.18	
Cal. F. Values		6.91**	16.05**	25.22**	

1/ Hybrid E 67 was produced by the Amalgamated Sugar Company

2/ Hybrid 0539H1 was produced by Dr. J. S. McFarlane

VARIETY TEST, JEROME, IDAHO, 1961

8 X 8 Latin Square

TEST I

Planted April 12, 1961
Harvested October 18, 1961

VARIETY	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT CURLY-TOP AUG. 2	BEETS 100' ROW
9140	7121 MS mm X CT5B	11,388	33.5	17.0	0.0	117
0457	630 aa X CT5	10,958	32.4	16.9	1.8	108
E 67[1/]	CT9 MS X mm	10,605	31.4	16.9	3.8	105
0110	211H3 X CT5 mm	10,592	32.0	16.6	0.0	108
9122A	7121 MS X CT5A	10,581	32.0	16.6	1.0	110
0539H1[2/]	7515 MS mm X 7569	9,976	30.2	16.5	2.5	110
0179	MS mm X CT5 mm	9,689	28.7	16.9	0.0	109
0462	CT8 aa X Line 289	8,648	23.4	18.5	6.5	104
General MEAN of all varieties		10,305	30.4	17.0		109
S. E. of MEAN		243	0.76	0.16		
Sig. Diff. (19:1)		695	2.18	0.45		
S. E. of MEAN in % of MEAN		2.36	2.50	0.94		
Cal. F. Values		12.24**	17.65**	16.05**		

[1/] E 67 was produced by the Amalgamated Sugar Company

[2/] Hybrid 0539H1 was produced by Dr. J. S. McFarlane

[3/] This test was planted on the same field as last year and culture practices the same. For detailed information refer to page 19, 1960 report. The sugar analyses were determined by the Amalgamated Sugar Company at Nyssa, Oregon

VARIETY TEST, LOGAN, UTAH, 1961

3 replications of each variety — TEST III

S.L. NUMBER	DESCRIPTION	PLACEMENT	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. Amino N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
0503	SLC 129	3	4,521	15.2	14.9	84.4	6130	263	2703	88
0504	do.	2	4,759	16.2	14.7	82.9	6030	270	2833	100
0520	Line 9508	6	4,301	14.3	15.1	85.4	4300	670	2326	87
0521	do.	5	4,385	16.2	13.6	82.3	5600	410	2620	92
0522	do.	8	3,579	12.9	15.0	82.2	6030	320	2363	79
0523	CT5 mm	11	3,150	10.0	15.7	83.6	4970	280	1896	80
0524	943	1	4,975	16.2	15.4	82.2	6630	277	2380	87
0525	SLC 132	4	4,448	15.8	14.0	80.7	7800	443	2760	72
0529	SLC 122 sublines	7	4,158	15.1	13.7	82.7	4070	470	2773	82
0552	CT5 mm	9	3,466	11.3	15.4	83.6	7000	290	1993	86
0553	do.	10	3,297	10.4	15.7	84.2	6960	247	1763	66
General MEAN of all varieties			4,094	13.96	14.83	83.11	5958	334	2401	
S. E. of MEAN			384	1.36	0.25	NS	NS	56.68	177.10	
Sig. Diff. (19:1)			1135	4.02	0.72	NS		167.50	523.0	
S. E. of MEAN in % of MEAN			9.38	9.74	1.69	--	--	1.70	7.37	
Cal. F. Values			2.60*	3.24*	9.89**	NS	NS	20.42**	4.55**	

DESCRIPTION OF VARIETIES IN TEST II

LOGAN, UTAH, 1961

VARIETY	DESCRIPTION	
9121	7121 MS mm	X CT5 rr
9122A	do.	X CT5A
9140	do.	X CT5B
0103	US 22 MS	X CT5.501
0105	do.	X 916, LSR
0106	do.	X Price 833-1
0107	do.	X Group A, Nematode selections
0108	do.	X Group B, do. do.
0110	do.	X CT5 mm
0111	do.	X (CT5.CT9) mm
0112	do.	X 132 mm
0120	do.	X 95.5.1 mm
0121	9132 MS mm	X 631
0122	do.	X Line 289
0123	9136 MS mm	X 9400, LSR
0125	9136 MS mm	X 50+10
0126	do.	X Line 289
0129	9142 MS mm	X 630
0130	9142 MS mm	X CT5.501
0131	9145 MS mm	X 50+10
0132	9145 MS mm	X Price 833-1
0156	9142 MS mm	X (CT5 mm)
0157	do.	X 132 mm
0167	9145 MS mm	X 95.5.5 mm
0176	AI (10X12)	X CT5 mm
0179	9132 MS mm	X CT5 mm
0198	9145 MS mm	X Group A, Nematode selections
0199	do.	X Group B, do. do.
028	US 41	
0464	431+5	X Line 289

VARIETY TEST, LOGAN, UTAH, 1961

6 replications of each variety

TEST II

S. L. NUMBER	Place-ment	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. Amino N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
9121	18	7,141	24.2	14.9	84.2	5800	470	2470	104
9122A	15	7,409	24.5	15.1	83.1	6000	410	2280	107
9140	7	7,893	26.5	14.9	84.3	6400	450	2400	107
0103	14	7,443	24.9	14.9	81.8	6400	530	2370	107
0105	29	6,497	23.2	13.9	82.0	5600	570	2620	101
0106	13	7,485	27.0	13.9	81.5	5800	740	2640	103
0107	8	7,776	27.6	14.0	83.2	6100	610	2620	102
0108	6	7,981	28.2	14.1	82.1	6000	560	2680	104
0110	17	7,297	24.1	15.1	84.0	5400	420	2380	104
0111	11	7,681	26.0	14.7	83.6	5400	460	2460	111
0112	9	7,701	28.1	13.8	81.4	6200	640	2590	101
0120	21	7,037	23.7	14.8	82.3	6100	470	2510	103
0121	19	7,116	23.5	15.2	82.9	6800	410	2560	96
0122	22	7,005	22.9	15.3	82.9	6000	360	2220	100
0123	5	8,117	26.6	15.3	82.4	5600	540	2470	111
0125	24	6,943	24.6	14.0	82.4	5500	510	2680	102
0126	12	7,528	23.9	15.7	84.3	6200	340	2140	101
0129	10	7,685	26.5	14.5	82.8	5900	480	2480	117
0130	2	8,410	26.4	15.9	83.3	6000	460	2150	108
0131	27	6,793	24.6	13.8	81.6	6200	440	2850	96
0132	4	8,260	29.0	14.1	81.9	5100	470	2540	109
0156	23	7,041	22.5	15.6	86.1	4300	300	2040	103
0157	16	7,372	25.9	14.2	83.2	6600	720	2720	106
0167	28	6,623	21.6	15.4	83.1	5800	320	2290	108
0176	30	5,939	19.8	15.1	83.4	5800	390	2280	112
0179	26	6,822	22.8	15.0	83.8	5400	380	2240	104
0198	3	8,386	29.9	14.1	83.0	4800	500	2470	111
0199	1	8,526	30.4	13.9	82.6	5400	530	2670	114
028	25	6,922	24.4	14.2	82.5	6300	610	2730	100
0464	23	6,995	22.6	15.5	82.0	7500	420	2160	100
General MEAN of all varieties		7,394	25.2	14.7	82.9	5888	487	2458	
S. E. of MEAN		305	0.96	0.25	NS	NS	56.7	93.6	
Sig. Diff. (19:1)		854	2.69	0.71			158.8	262.0	
S. E. of MEAN in % of MEAN		4.12	3.81	1.70			11.64	3.81	
Cal. F. Values		4.02**	6.63**	6.41**	NS	NS	3.64**	4.79**	

TEST WITH SALT LAKE CITY VARIETIES
BRAWLEY, CALIFORNIA, 1960-61

6 replications each variety

By K. D. Beatty and
F. V. Owen

VARIETY	DESCRIPTION	TONS PER ACRE	ROOT SIZE CODE	BOLTING PERCENT	BEETS 100' ROW
9101	US 22 MS X CT5B	25.1	1.8	44.9	138
9140	7121 MS mm X CT5A	25.0	1.7	44.6	136
0106	US 22 MS X Price 833-1	25.0	1.7	2.0	145
0110	US 22 MS X CT5 mm	24.4	2.0	10.9	133
0114	do. X SLC 132 mm	23.3	1.8	0	119
9100	US 22 MS X CT5B	23.2	1.9	15.3	136
0103	do. X CT5.501	23.1	1.5	41.2	130
0132	9142 MS mm X Price 833-1	22.7	1.3	0.4	118
0130	do. X CT5.501 mm	22.4	1.7	8.4	134
H2	F59-63H1	22.2	1.8	0.6	133
9121	7121 MS mm X CT5A	21.9	2.2	56.0	125
0457	SL 630 aa X 94.55 of CT5 M	21.2	1.5	53.2	123
0101	US 22 MS X SL 630 M	21.0	2.0	14.5	118
0453	CT5B aa X SL 631 MM	20.1	2.0	7.4	135
929	9142 MS mm X SL 630 M	19.1	2.3	3.9	127
0111	US 22 MS X 943 mm	18.7	2.5	11.3	129
0121	9132 MS mm X SL 631 M	18.1	2.3	1.0	130
0102	US 22 MS X SL 631 M	18.3	2.5	3.4	111
0464	431+5 X 5080 M	17.9	2.8	2.5	135
0120	US 22 MS X 955.1 mm etc.	17.7	2.2	0.6	122
0143	9136 MS mm X SLC 129 mm	16.8	2.8	0.6	122
0149	do. X 943 mm	16.8	3.2	17.8	129
0179	9132 MS mm X CT5 mm	16.3	2.8	5.5	133
0148	9136 MS mm X CT5 mm	15.7	2.8	13.9	117
0176	Amal. (10X12) MS mm X SLC 129 mm	15.3	3.2	26.7	136
0157	9142 MS mm X SLC 132 mm	15.0	3.2	0	118
0156	do. X CT5 mm	14.8	3.0	9.4	110
0173	Amal. (10X12) MS mm X SLC 129 mm	13.0	3.7	1.6	132
0158	9142 MS mm X 95.5.1 mm	12.4	3.0	1.4	123
0178	Amal. (10X12) MS mm X SLC 129 mm	11.4	4.0	3.8	121

Planted September 15, 1960
Harvested April 18, 1961

TEST WITH SALT LAKE CITY VARIETIES
BRAWLEY, CALIFORNIA, 1960-61

By K. D. Beatty and
F. V. Owen

1 replication only each variety

VARIETY	DESCRIPTION	TONS PER ACRE	ROOT SIZE GRADE	BOLTING PERCENT	BEETS 100' ROW
9450	CT5B+O	15.2	3	62.9	175
0523	CT5 mm monogerm	16.2	2	22.6	133
0524	943 mm	11.7	3	3.8	133
0503	SLC 129 mm	9.5	4	0	130
0267	(129 aa X CT5 mm)	18.2	3	0	130
0529	SLC 122-19 subline, monogerm	9.0	4	0	120
0543	95.5.5 mm	7.1	4	7.5	133
0080		4.7	5	0	93
7867	CT8	8.5	4	0	135
0463	CT8 aa X 289 multigerm	16.1	3	0	183
9470	Munerati annual	15.6	3	55.0	135
44460HO	BMS annual	18.4	3	24.0	125
04500	BB rr mm, monogerm	11.0	4	31.0	105
84602	Intermediate annual S6	12.2	4	0	98
04553	F_2B_6 CT5 annual	21.1	3	85.7	123
04555	F_2B_7 CT5 annual	15.4	3	84.9	155
9051	CT5A	17.1	3	49.1	138
9054	CT5 from 82.507	17.3	3	0	155
0001	CT5 from 92.501	16.2	3	80.0	128
0002	CT5 from 94.55	16.9	3	16.7	135

SPECIAL VARIETY TEST WEST JORDAN, UTAH, 1961

6 Replicated Plots Of Each Variety

Conducted by Utah-Idaho Sugar Company
under the supervision of Bert Atwater

	Variety		Gross Sugar lbs.	Acre Yield Tons Beets	Percent Sucrose
1.	0107	Code 3x Group A	8137	26.1	15.6
2.	028	Us 41	8126	27.3	14.9
3.	0108	Code 3x Group B	8062	25.8	15.6
4.	0110	Code 3x 924 (CT5 mm)	7886	25.9	15.2
5.	0179	Code 32 x 924 (CT5)	7840	25.3	15.5
6.	9122A	7121 x CT5 A	7698	25.7	15.0
7.	S.L. 202		7698	25.5	15.1
8.	0156	Code 2 x 924 (CT5)	7542	24.8	15.2
9.	0123	Code 36 x 9400 LSR	7481	24.3	15.4
10.	0176	(10 x 12) x 924 (CT5)	7474	24.1	15.5
11.	9121	7121 x CT5 rr	7435	25.3	14.7
12.	0126	Code 36 x 5080	7356	24.0	15.3
13.	122 x (CT5 x 110 x CT9) C		7030	22.4	15.7
14.	0122	Code 32 x 5080	6972	22.5	15.5
15.	0121	Code 32 x 631	6956	23.7	14.7
16.	0105	Code 3 x 916	6922	22.6	15.3
17.	0112	Code 3 x 132 mm	6882	22.2	15.5
18.	122 x U & I 110 C		6762	22.5	15.0
19.	0106	Code 3 x 833 - 1	6744	22.6	14.9
20.	0198	Code 45 x Group A	6637	21.7	15.3
21.	122 x SL 340 4N C		6575	21.6	15.2
22.	0111	Code 3 x 943 (CT5 CT9)mm	6556	22.3	14.7
23.	122 x SP 5651-0 C		6405	21.3	15.0
24.	0129	Code 2 x 630	6271	20.6	15.2
25.	0199	Code 45 x Group B	6256	20.2	15.5

SPECIAL VARIETY TEST WEST JORDAN, UTAH, 1961

6 Replicated Plots of Each Variety

	Acre Yield		
	Gross Sugar lbs.	Tons Beets	Percent Sucrose
General MEAN of all varieties	7188	23.6	15.2
S. E. of MEAN	460	1.41	.35
Sig. Diff. (19:1)	1300	3.98	NS
S.E. OF MEAN in % of MEAN	6.40	5.97	2.30

(Odds 19:1 = 2/2 x Standard Error of Mean. NS = F value not significant.)

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar lbs.	Tons Beets	Percent Sucrose
Between varieties	24		22.07	.534
Between blocks	5		36.71	4.36
Remainder (Error)	120		11.86	.735
Total	149		1.86*	NS

Calculated F Value

* Exceeds the 5% point of significance (F = 1.60)
** Exceeds the 1% point of significance (F = 1.94)

Sugar Beet Variety Test, University Park, New Mexico, 1961
In cooperation with the New Mexico Agricultural Experiment Station

By J. C. Overpeck

The annual field test showed yields ranging from 18.9 tons to 34.0 tons to the acre. Curly top was as severe as ever noted in any past year. 202H9, which scarcely showed any curly top, was highest in yield by a wide margin, and other varieties yielded in proportion to the severity of curly top.

Cercospora leaf spot was most severe on varieties which seemed most resistant to curly top, but during the last 2 months before harvest the injury was much less noticeable; and although it may have adversely affected the percentage of sucrose, it did not seem to affect seriously the final yields.

In an observational unreplicated test, SP 6051-0 showed practically no curly top and very marked resistance to leaf spot. It was probably the outstanding variety in the entire test.

SUGAR BEET VARIETY TEST, UNIVERSITY PART, NEW MEXICO

In cooperation with New Mexico Agricultural Experiment Station

(Results given as 6-plot averages)

Variety		Root yield (tons/acre)	Curly top readings[1/] (7/11)	(8.5)	(9.4)
SL 202H9 (multigerm)		34.0	1.0	1.0	2.2
R 5651 (multigerm)		21.4	1.7	2.7	3.2
SL 122MS mm X SP 5460-0 (commercial monogerm)		21.8	2.3	4.2	3.8
SP 60106-01 (monogerm)		18.9	3.2	4.0	4.3
SP 60107-01	do	22.8	2.7	4.0	4.0
SP 60114-01	do	23.2	2.5	4.3	4.5
SP 60115-01	do	19.6	4.0	4.8	5.0
SP 60119-01	do	22.3	3.0	4.7	3.8
SP 60120-01	do	19.9	2.8	4.3	4.5
LSD (P = .05)		5.2			
LSD (P = .01)		6.9			
SL 333 not an entry in replicated test		14.7	3.8	5.5	7.8

1/ Low readings best in resistance; 10 indicates total loss due to curly top.

Leaf spot developed to epidemic proportions in September and influenced curly top readings and relative root yields of varieties.

Test planted March 17 and harvested December 12, 1961.

For further information on research to combine resistance to curly top and leaf spot, see Parts V and XII.

P A R T IV

DEVELOPMENT AND EVALUATION OF SUGARBEET VARIETIES SUITABLE FOR THE GREAT LAKES REGION

Breeding to Combine Resistance to Leaf Spot and Black Root in High Quality Lines and Productive Varieties

- - -

Evaluation of Miscellaneous Varieties

Foundation Project 26

G. E. Coe
C. L. Schneider

Dewey Stewart

H. W. Bockstahler
G. J. Hogaboam

Cooperators conducting field tests:

Farmers & Manufacturers Beet Sugar Association
Buckeye Sugars, Inc.
Canada and Dominion Sugar Company, Ltd.
The Great Western Sugar Company
Menominee Sugar Company
Michigan Sugar Company
Monitor Sugar Division
Northern Ohio Sugar Company
Michigan Agricultural Experiment Station
Western Ontario Agricultural School, Ridgetown, Ontario

EVALUATION OF BASIC BREEDING MATERIAL AND VARIETIES SUITABLE FOR THE GREAT LAKES REGION

Dewey Stewart

The cooperative variety trials of 1961 in the Great Lakes region were planned primarily to evaluate regional adaptation of inbred lines, synthetic varieties, and hybrids developed in sugarbeet breeding conducted at the Plant Industry Station, Beltsville, Maryland, and the Michigan Agricultural Experiment Station, East Lansing, Michigan. The Farmers & Manufacturers Beet Sugar Association supplied commercial seed as well as seed of experimental hybrids.

Summary of 8 Latin square experiments is given on page 88. The relative performances of the varieties in acreable yield of roots and sugar, percentage sucrose, and purity were profoundly influenced by leaf spot and to some extent by black root. Leaf spot occurred in observable intensity in 6 of the 8 experiments included in the summary. In three of the tests, leaf spot reached epidemic proportions and disease readings are given indicating the relative tolerance of the varieties.

The disease was also severe in the test at Findlay, Ohio (page 104), and East Lansing, Michigan (page 98). The incidence of leaf spot in the various cooperative tests clearly indicates that 1961 was a favorable year for leaf spot in the Great Lakes region.

The summary of the field tests indicated a higher acreable yield in roots and gross sugar for the multigerm variety SP 5481-0 (US 401) than for the monogerm hybrid SL 122MS X SP 5460-0. However, the average sucrose percentage for the monogerm hybrid is slightly higher than that of the multigerm variety. It is of interest to note that the monogerm and multigerm varieties gave similar relative performance for sucrose percentage in cooperative tests of 1960 (see 1960 Report, page 267). In the summary of nine cooperative tests of 1960, the average acreable yields of roots and gross sugar for the monogerm hybrid and multigerm variety were similar; therefore, the significant differences shown for these attributes in 1961 are probably a reflection of relative differences in disease tolerance.

Attention is directed to the excellent performances of the synthetic monogerm varieties SP 60194-01 and SP 60195-01, which were developed by G. E. Coe in a program of backcrossing. The parental lines were discriminately chosen from greenhouse screening tests conducted for black root resistance by C. L. Schneider and from field tests conducted under leaf spot and black root exposure at Beltsville, Maryland; East Lansing, Michigan; and Waseca, Minnesota. Performance evaluations were conducted near Saginaw, Michigan, by the Farmers & Manufacturers Beet Sugar Association. The monogerm varieties are more resistant to leaf spot than the multigerm SP 5481-0 (US 401), and under the conditions of these tests their average values for the attributes of acreable yield of roots and gross sugar and sucrose percentage did not differ statistically from those of the multigerm variety.

The multigerm hybrid NB1 MS X EL 42 has the highest average acreable yield of roots and gross sugar of the varieties included in the summary table. The inbred line NB1 used as seed parent was developed by J. S. McFarlane and the pollinator, EL 42, by H. L. Kohls, Michigan Agricultural Experiment Station.

DESCRIPTION OF ENTRIES IN FIELD AND NURSERY TRIALS OF 1961

Entry No.		Description
SP 6045-0	-	Monogerm synthetic variety produced by interpollination of selfed progenies of 11 plants producing good polycross progeny.
SP 60194-01 SP 60195-01 SP 60196-01	-	Monogerm varieties obtained from backcross progenies.
WC 0463	-	Increase of SP 591103-0 (Gaskill), which is an increase of PI 254,575 - Russian monogerm.
WC 0465	-	Increase of SP 59H5-0, a selection (Wallaceburg, Ont.) from Monogerm SP 5832-0.
SP 6059-0	-	Multigerm synthetic variety from the interpollination of 8 clones that were excellent in resistance to leaf spot and black root.
SP 5937-0	-	Multigerm synthetic variety from the interpollination of 8 clones which produced polycross progeny of good purity.
9921 H1	-	Triploid hybrid from McFarlane (see Part VII of 1960 Report).
9921 H2	-	Triploid hybrid from McFarlane (see Part VII of 1960 Report).
SP 6046-01	-	Triploid (SL 122MS $2^{\underline{n}}$ X SP 573040-0 MM $4^{\underline{n}}$)
SP 6046-02	-	Triploid (SP 5720-05 WA $2^{\underline{n}}$ X SP 573040-0 MM $4^{\underline{n}}$)
SP 6047-01	-	Triploid (SL 122MS $2^{\underline{n}}$ X US 401 $4^{\underline{n}}$)
SP 6047-02	-	Triploid (SP 5720-04 WA $2^{\underline{n}}$ X US 401 4^{n})
SP 6048-01	-	Diploid (SL 122 MS X US 401)
SP 6048-02	-	Diploid (SP 5720-04 WA X US 401)
SP 6049-01	-	Diploid (SL 122MS X SP 6052-01 MM)

SP 6056-0 - Synthetic variety from interpollination of selfed progeny of 4 plants producing polycross progeny of high purity.

SP 603103-01 - Increase of SP 573040-0 $4^{\underline{n}}$ multigerm.

SP 60106-01
SP 60109-01
SP 60113-01 - F_3 monogerm lines derived from crossing of leaf spot-black root resistant monogerm lines X leaf spot-curly top resistant multigerm lines.
SP 60114-01
SP 60115-01

SP 59B18-0 - 02 clone X 7 clones of US 401.

SP 59B18-01 - 7 clones of US 401 interpollinated and receiving some pollen from 02 clone.

SP 56AB1-45 - 02 clone X SP 56AB1 - polycross.

SL 122MS <u>mm</u> X SP 5460-0 MM
- Commercial monogerm hybrid.

SP 5481-0 - A phase of US 401.

SL 122MS <u>mm</u> X EL 42
- EL 42 is multigerm with black root and leaf spot resistance. Developed by H. L. Kohls as a subline from his No. 345.

NB1 X EL 42 - NB1 developed by J. S. McFarlane.

Leaf Spot Readings at Beltsville, Md. in 1961

Variety & Description	Leaf Spot Reading Aug.1	Aug.12
VARIETIES IN EASTERN FIELD TRIALS		
SP 6045-0 mm synthetic from selfed seed.	4.6	5.3
SP 60194-01 O.P. mm recovered from Backcross	3.4	4.3
SP 60195-01 " " " " "	3.2	4.0
SP 60196-01 " " " " "	4.0	5.0
SL 122 MS mm X EL 42 MM	4.1	5.1
NB 1 MS MM X EL 42 MM	3.3	4.5
SL 122 MS mm X SP 5460-0	5.2	5.5
SP 5481-0 MM	4.3	5.1
CTR-LSR VARIETIES IN FIELD TRIALS		
Acc 2270 SL 122 MS mm X SP 5651-0 MM	4.8	5.8
Acc 2271 SL 122 MS X (SL 114 X 601) X U I 13)	4.3	5.8
Acc 2272 CT 9 MS X US 22/3	5.1	5.9
Acc 2273 SP 6051-0 MM	3.1	4.6
Acc 2274 SP 60100-00 O.P. mm recovered from Backcross	4.4	5.0
Acc 2286 SL 122 MS mm X SP 5460-0 MM	4.8	5.8
Acc 2383	5.1	6.0
SP 581813-00 MM	3.1	4.4
CHECKS		
U.S. 201	2.0	2.0
Acc. 2269 Susceptible Check	5.8	6.8
VARIETIES IN EAST LANSING AND MERRILL NURSERIES		
W.C. 0463 SP 591103-0 mm (PI 254575 from Russia)	5.0	6.4
W.C. 0465 SP 59E5-0 mm	4.1	4.9
SP 56AB1-45 MM	3.5	4.5
SP 59B18-0 02 00 00 MM clone X U.S. 401 (7 selected plants)	3.2	4.0
SP 59B18-01 U.S. 401(7 selected plants) X 02 00 00 MM clone	3.2	4.5
9921H1	5.2	5.7
9921H2	5.4	5.7
SP 5937-0 mm synthetic from clones	4.3	4.8
SP 6046-01 SL 122 MS mm X SP 603103-01 4n MM	3.3	4.3
SP 6046-02 SP 5720-01 WA X SP 603103-01 4n MM	3.3	4.0
SP 6047-01 SL 122 MS mm X U.S. 401 4n	4.6	5.2
SP 6047-02 SP 5720-01 mm WA X U.S. 401 4n	4.9	5.0
SP 6048-01 SL 122 MS mm X U.S. 401	4.9	5.5
SP 6048-02 SP 5720-01 WA mm X U.S. 401	5.2	5.8
SP 6049-01 SL 122 MS mm X SP 6052-01 MM Inbred	4.3	5.2
SP 6056-0 MM synthetic from selfed seed	3.5	3.8
SP 6059-0 MM " " Clone	3.9	4.6
SP 60106-01 O.P. mm recovered from Backcross	4.0	5.0
SP 60109-01 " " " " "	4.0	4.8
SP 60113-01 " " " " "	4.0	4.8
SP 60114-01 " " " " "	3.5	4.8
SP 60115-01 " " " " "	4.0	5.0
SP 603103-01 4n MM (Inbred from SP 5460-0)	3.0	3.8

Summary of Latin Square experiments conducted by U.S.D.A., Year: 1961
F. and M. Beet Sugar Association and member Companies. Eight experiments analyzed and tested with Variety X Location interaction (except only six expts. analyzed for % purity as no data available for the two expts. from Canada).

Locations: Ridgetown and Chatham, Ontario; Sebewaing, Croswell, Kawkawlin, and Bay City, Michigan; Pandora, Ohio; and Chilton, Wisconsin.

Variety or Seed Number		Acre-Yield: Gross Sugar Pounds	Acre-Yield: Roots Tons	Sucrose Percent	Purity Percent	Beets per 100' of row Number
S.P.6045-0	(mm)	5253.5	17.190	15.306	83.401	88.1
S.P.60194-01	(mm)	6089.3	19.224	15.874	83.922	95.0 92
S.P.60195-01	(mm)	5995.1	18.849	15.946	83.683	94.3 94
S.P.60196-01	(mm)	5835.1	18.190	16.090	83.970	96.5 87
S.L.122MS X E.L.42	(Mm)	6027.8	19.240	15.710	83.443	88.0
NB 1 X E.L.42	(MM)	6496.8	20.920	15.574	83.577	87.5
S.L.122MS X 5460-0	(Mm)	5711.4	18.101	15.861	83.797	94.3
S.P.5481-0	(MM)	6094.4	19.394	15.744	83.627	91.9
General Mean		5937.9	18.888	15.763	83.678	91.9
S.E. Var. Mean		96.75	0.3080	0.0868	0.2333	1.48
S.E. Var. Mean as % Gen. Mean		1.63	1.63	0.55	0.28	1.61
Diff. for sig. (19:1)		274.7	0.874	0.246	NS	4.2
(99:1)		366.4	1.166	0.328	NS	5.6

Comp BRR

Variety X Location Analysis — Variance Table

Source of Variation	D/F: Purity	D/F: All Others	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between Locations	5	7	9,770,970	115.6251	6.2211	45.8614	872
Between Varieties	7	7	1,030,094	9.8427	0.4686	0.2598	104
Varieties X Locations	35	49	74,878	0.7582	0.0601	0.3264	17
Total	47	63					
Calculated F value	7/35	7/49	13.76**	12.98**	7.79**	0.80 NS	5.94**

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett

Location: Harold Gremel farm, Sebewaing, Mich.

Cooperation: F. & M. Sugar Association, Michigan Sugar Co.

Date of Planting: April 13, 1961

Date of Harvest: October 27, 1961

Experimental Design: 8 x 8 Latin Square

Size of Plots: 6 rows x 28 feet, 28 inches between rows

Harvested Area per Plot for Root Yield: 4 rows x 26 feet

Samples for Sucrose Determination: 2 samples of 8 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed

Recent Field History:	1960	Beans	250#	6-24-12
	1959	Corn	300#	6-24-12
	1958	Hay		

Fertilization of Beet Crop: 800# 6-24-12

Black Root Exposure: Slight

Leaf Spot Exposure: Moderate

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seedbed, generally good growing conditions throughout the season.

Reliability of Test: Good

Cooperator: F. and M. Beet Sugar Association, Michigan Sugar Company. Year: 1961

Location: Harold Gremel farm, Sebewaing, Michigan. Expt: 1

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
		Pounds	Tons	Percent	Percent	Number	Rating
S.P.6045-0	(mm)	6997	23.41	14.95	81.74	81	3.0
S.P.60194-01	(mm)	7812	25.43	15.38	82.01	87	2.0
S.P.60195-01	(mm)	7735	24.83	15.59	82.69	84	1.3
S.P.60196-01	(mm)	7827	24.59	15.92	82.53	91	1.6
S.L.122MS X E.L.42	(Mm)	7968	26.36	15.12	81.68	81	2.5
NB 1 X E.L.42	(MM)	8809	29.58	14.91	82.29	85	1.6
S.L.122MS X 5460-0	(Mm)	7551	25.22	14.96	81.63	85	4.8
S.P.5481-0	(MM)	7316	23.95	15.29	81.97	82	2.1
General Mean		7752	25.42	15.26	82.07	84	2.4
S.E. Var. Mean		210.8	.5898	.1800	.4465	2.7	0.20
S.E. Var. Mean as % Gen. Mean		2.72	2.32	1.18	0.54	3.19	8.33
Diff. for Sig. (odds 19:1)		602	1.68	0.51	NS	NS	0.6

Latin Square Analysis Variance Table

Source of Variation	D/F	Mean Squares Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
Between rows	7	2,100,714	29.609	2.730	19.468	57	1.14
Between columns	7	876,389	5.138	853	2.655	166	0.71
Between varieties	7	2,255,642	29.185	1.012	1.554	90	9.86
Remainder - Error	42	355,629	2.783	259	1.595	58	0.31
Total	63						
Calculated F. value	7/42	6.34**	10.49**	3.91**	NS	NS	31.80**

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett.

Location: Herman Gies farm, Kawkawlin, Michigan.

Cooperation: F. and M. Beet Sugar Association, Monitor Sugar Division.

Date of Planting: May 11, 1961.

Date of Harvest: October 23, 1961.

Experimental Design: 8 x 8 Latin Square.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History:	1960	Beans	250#	6-24-12
	1959	Beans	250#	6-24-12
	1958	Wheat	300#	6-24-12

Fertilization of Beet Crop: 600# 5-20-10

Black Root Exposure: Slight.

Leaf Spot Exposure: Moderate.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed, generally good growing conditions throughout the season.

Reliability of Test: Good.

Cooperator: F. and M. Beet Sugar Association, Monitor Sugar Division. Year: 1961

Location: Herman Gies farm, Kawkawlin, Michigan. Expt: 5

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
		Pounds	Tons	Percent	Percent	Number
S.P.6045-0	(mm)	4599	14.44	15.91	87.33	94
S.P.60194-01	(mm)	5476	16.35	16.70	87.17	94
S.P.60195-01	(mm)	5515	16.12	17.09	88.13	96
S.P.60196-01	(mm)	5327	15.68	16.98	87.32	97
S.L.122MS X E.L.42	(Mm)	5556	16.62	16.69	86.65	90
NB 1 X E.L.42	(MM)	6369	18.89	16.85	88.54	91
S.L.122MS X 5460-0	(Mm)	5179	15.20	16.99	87.62	99
S.P.5481-0	(MM)	5757	17.15	16.78	88.03	96
General Mean		5472	16.31	16.75	87.60	95
S.E. Var. Mean		164.4	.3476	.2361	.4684	2.8
S.E. Var. Mean as % Gen. Mean		3.00	2.13	1.41	0.53	2.95
Diff. for Sig. (odds 19:1)		469	0.99	0.67	NS	NS

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	7	236,250	841	605	1.697	183
Between columns	7	620,176	3.472	453	1.673	348
Between varieties	7	2,154,416	14.483	1.092	2.677	71
Remainder - Error	42	216,260	967	446	1.755	62
Total	63					
Calculated F. value	7/42	9.32**	14.98**	2.45*	NS	NS

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett

Location: Victor Beslaer farm, Essexville, Mich.

Cooperation: F. & M. Beet Sugar Association, Monitor Sugar Division

Date of Planting: April 20, 1961

Date of Harvest: October 17, 1961

Experimental Design: 8 x 8 Latin Square

Size of Plots: 6 rows x 28 feet, 28 inches between rows

Harvested Area per Plot for Root Yield: 4 rows x 26 feet

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed

Recent Field History:

1960	Beans	300#	4-16-16
1959	Corn	500#	3-12-12

Fertilization of Beet Crop:

400#	0-20-20	broadcast
550#	4-16-16	banded

Black Root Exposure: Slight

Leaf Spot Exposure: Moderate

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seedbed. Generally good growing conditions throughout the season.

Reliability of Test: Good

Cooperator: F. and M. Beet Sugar Association, Monitor Sugar Division. Year: 1961

Location: Victor Beslaer farm, Essexville, Michigan. Expt: 6

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
		Pounds	Tons	Percent	Percent	Number	Rating
S.P.6045-0	(mm)	5526	18.48	14.74	84.41	91	2.9
S.P.60194-01	(mm)	6719	21.69	15.40	84.13	100	1.5
S.P.60195-01	(mm)	7006	22.57	15.47	83.40	97	1.3
S.P.60196-01	(mm)	6939	21.61	16.05	84.75	101	1.6
S.L.122MS X E.L.42	(Mm)	6979	22.91	15.21	83.61	92	2.3
NB 1 X E.L.42	(MM)	7632	25.55	14.94	82.95	91	1.8
S.L.122MS X 5460-0	(Mm)	6520	21.42	15.21	84.03	96	4.4
S.P.5481-0	(MM)	6661	21.83	15.19	83.80	89	1.8
General Mean		6748	22.01	15.28	83.89	94	2.2
S.E. Var. Mean		300.4	.7381	.2769	.6785	2.4	.225
S.E. Var. Mean as % Gen.Mean		4.45	3.35	1.81	0.80	2.55	10.37
Diff. for Sig. (odds 19:1)		857	2.11	NS	NS	7	0.7

Latin Square Analysis Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100'	Leaf Spot
Between rows	7	3,083,314	18.870	1.441	1.575	68	1.00
Between columns	7	1,195,306	12.529	1.070	5.914	77	0.71
Between varieties	7	2,847,200	30.689	1.264	2.815	151	8.29
Remainder - Error	42	722,093	4.359	613	3.683	47	0.41
Total	63						
Calculated F. value	7/42	3.94**	7.04**	NS	NS	3.20**	20.46**

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett

Location: Reed Gordon farm, Croswell, Mich.

Cooperation: F. & M. Beet Sugar Association, Michigan Sugar Co.

Date of Planting: May 23, 1961

Date of Harvest: October 14, 1961

Experimental Design: 8 x 8 Latin Square

Size of Plots: 6 rows x 28 feet, 28 inches between rows

Harvested Area per Plot for Root Yield: 4 rows x 26 feet

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random

Stand Counts: Harvested beets counted when weighed

Recent Field History:

1960	Pasture	10 tons manure/acre
1959	Hay	No fertilizer
1958	Oats	250# 6-24-12

Fertilization of Beet Crop: 500# 6-24-12

Black Root Exposure: Slight

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seed bed. Generally good growing conditions throughout the season.

Reliability of Test: Fair

Cooperator: F. and M. Beet Sugar Association, Michigan Sugar Company. Year: 1961

Location: Reed Gordon farm, Croswell, Michigan. Expt: 4

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
		Pounds	Tons	Percent	Percent	Number
S.P.6045-0	(mm)	3931 8	13.83 7	14.25 7	80.95 4	80
S.P.60194-01	(mm)	4564 2	15.40 2	14.82 2	81.94 1	86
S.P.60195-01	(mm)	4240 5	14.82 5	14.35 6	80.40 8	84
S.P.60196-01	(mm)	4436 3	15.01 3	14.79 3	80.77 6	85
S.L.122MS X E.L.42	(Mm)	4296 4	14.88 4	14.45 4	81.10 3	84
NB 1 X E.L.42	(MM)	3994 7	14.60 6	13.73 8	79.57 7	78
S.L.122MS X 5460-0	(Mm)	4163 6	13.75 8	15.14 1	81.64 2	85
S.P.5481-0	(MM)	4725 1	16.42 1	14.43 5	80.88 5	89
General Mean		4294	14.84	14.50	80.91	84
S.E. Var. Mean		141.4	.4571	.1670	.6054	3.2
S.E. Var. Mean as % Gen. Mean		3.29	3.08	1.15	0.75	3.18
Diff. for Sig. (odds 19:1)		404	1.30	0.47	NS	NS

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	7	678,121	7.732	1.037	8.371	213
Between columns	7	260,684	8.343	2.341	13.776	133
Between varieties	7	594,631	5.790	1.515	4.496	92
Remainder - Error	42	160,035	1.672	223	2.932	81
Total	63					
Calculated F. value	7/42	3.72**	3.46**	6.79**	NS	NS

AGRONOMIC EVALUATION TEST - 1961

Conducted by: G. J. Hogaboam, H. W. Bockstahler.

Location : M. S. U. farm, East Lansing, Michigan, North Nursery.

Cooperation : Michigan Agricultural Experiment Station- Farm Crops Dept.

Date of Planting : May 17,1961. Pre-emergence spray TCA & Endothal,5-19.

Date of Harvest : October 24, 1961. Hand topped.

Experimental Design : Latin Square 8 x 8 and Rectangular Lattice 5 x 6 (30 vars.) with 6 replications. Both tests in same field.

Size of Plots : 8 rows x 20 feet. 28" between rows.

Harvested Area per Plot for Root Yield : 6 rows x 20 feet. Hand topped.

Samples for Sucrose Determination : All beets in Row 2 of each plot taken for sample 1. All beets in Row 6 taken for sample 2. (See note under Leaf Spot Exposure).

Stand Counts : Harvested beets counted when weighed.

Recent Field History : Continuous beets (agronomic evaluation tests) since 1958. 1000# 12-12-12 plowed down.

Fertilization of Beet Crop : For 1961 crop- 1000# 12-12-12. Previous crops- 1000# 5-20-20.

Black Root Exposure : Moderate. Infected sorghum seed inoculum applied with beet seed at planting (second year).

Leaf Spot Exposure : Rows 1 and 2 of each plot inoculated with powdered beet leaf inoculum applied August 1 with knapsack hand duster. Infection spread to the remainder of the plot. Leaf spot readings were made September 29 showing an overall average rating of about 4.

Soil and Seasonal Conditions : Fall plowed, land leveled and spring-tooth harrowed in spring before planting. Adequate rainfall during growing season.

Reliability of Test : Fair to Good. Minor stand and yield adjustments were made on several plots due to cultivator, rhizoctonia, and water damage.

Cooperator: Michigan Agricultural Expt. Station-Farm Crops Dept. Year: 1961

Location: East Lansing, Michigan, M.S.U. Farm, North Nursery Expt: 10

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
		Pounds	Tons	Percent	Percent	Number	Rating
S.P.6045-0	(mm)	2904 6	11.50 7	12.44 4	82.35 3	90	3.6
S.P.60194-01	(mm)	3001 3	12.17 1	12.18 6	81.14 5	92	3.3
S.P.60195-01	(mm)	2980 4	11.85 3	12.40 5	80.78 7	90	3.1
S.P.60196-01	(mm)	3049 2	11.79 4	12.68 1	80.43 8	90	3.6
S.L.122MS X E.L.42	(Mm)	3083 1	12.16 2	12.61 2	82.10 4	89	3.5
NB 1 X E.L.42	(MM)	2771 7	11.55 6	11.83 8	82.50 1	92	3.6
S.L.122MS X 5460-0	(Mm)	2697 8	11.08 8	12.10 7	82.36 2	93	4.8
S.P.5481-0	(MM)	2953 5	11.71 5	12.49 3	80.90 6	86	3.5
General Mean		2930	11.72	12.34	81.57	90	3.6
S.E. Var. Mean		191.6	.4529	.4530	.9817	2.6	0.17
S.E. Var. Mean as % Gen. Mean		6.54	3.86	3.67	1.20	2.84	4.72
Diff. for Sig. (odds 19:1)		NS	NS	NS	NS	NS	0.5

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
Between rows	7	1,318,242	7.999	5.555	13.177	118	0.21
Between columns	7	820,471	2.886	6.057	16.116	50	0.68
Between varieties	7	143,904	1.069	714	5.814	41	1.93
Remainder - Error	42	293,659	1.641	1.642	7.711	53	0.22
Total	63						
Calculated F. value	7/42	NS	NS	NS	NS	NS	8.76**

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett

Location: George Schwarz farm, Chilton, Wisconsin.

Cooperation: F. & M. Beet Sugar Association, Menominee Sugar Company

Date of Planting: May 13, 1961

Date of Harvest: October 20, 1961

Experimental Design: 8 x 8 Latin Square

Size of Plots: 6 rows x 28 feet, 24 inches between rows

Harvested Area per Plot for Root Yield: 4 rows x 26 feet

Samples for Sucrose Determination: 2 samples of 8 beets each, selected at random

Stand Counts: Harvested beets counted when weighed

Recent Field History:

	1960	Sweet corn	8 tons/acre barnyard manure
	1959	Alfalfa	No fertilizer
	1958	Alfalfa	No fertilizer

Fertilization of Beet Crop: 200# 4-16-16 (8% Boron)

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seedbed, generally good growing conditions throughout the season.

Reliability of Test: Fair

Cooperator: F. and M. Beet Sugar Association, Menominee Sugar Company. Year: 1961

Location: George Schwarz farm, Chilton, Wisconsin. Expt: 7

(Results given as 8 plot averages)

Variety and Description		Acre-Yield: Gross Sugar	Acre-Yield: Roots	Sucrose	Purity	Beets per 100' of row
		Pounds	Tons	Percent	Percent	Number
S.P.6045-0	(mm)	5023 8	15.17 8	16.55 8	84.52 8	106
S.P.60194-01	(mm)	5866 2	17.24 2	17.03 3	85.31 2	116
S.P.60195-01	(mm)	5504 6	16.26 6	16.91 4	84.86 5	121
S.P.60196-01	(mm)	5205 7	15.21 7	17.11 2	85.17 3	115
S.L.122MS X E.L.42	(Mm)	5658 4	16.87 3	16.78 7	84.81 6	99
NB 1 X E.L.42	(MM)	6082 1	17.98 1	16.88 5	85.76 1	93
S.L.122MS X 5460-0	(Mm)	5594 5	16.34 5	17.16 1	84.75 7	117
S.P.5481-0	(MM)	5660 3	16.80 4	16.83 6	84.95 4	110
General Mean		5574	16.48	16.91	85.02	109
S.E. Var Mean		163.4	.4204	.1225	.3690	2.7
S.E. Var. Mean as % Gen. Mean		2.93	2.55	0.72	0.43	2.48
Diff. for Sig. (odds 19:1)		466	1.20	0.35	NS	[illegible]

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	7	1,632,285	12.993	459	426	447
Between columns	7	716,759	8.339	350	2.153	159
Between varieties	7	917,090	7.370	389	1.310	759
Remainder - Error	42	213,663	1.414	120	1.089	60
Total	63					
Calculated F. value	7/42	4.29**	5.21**	3.24**	NS	12.63

AGRONOMIC EVALUATION TEST - 1961

Conducted by: M. R. Berrett

Location: Louis Risser farm, Pandora, Ohio

Cooperation: F. & M. Beet Sugar Association, Buckeye Sugars, Inc.

Date of Planting: May 19, 1961

Date of Harvest: October 25, 1961

Experimental Design: 8 x 8 Latin Square

Size of Plots: 6 rows x 28 feet, 28 inches between rows

Harvested Area per Plot for Root Yield: 4 rows x 26 feet

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed

Recent Field History:	1960	Wheat	200# 8-8-8 & 200# 6-18-6
	1959	Soybeans	None
	1958	Corn	325# 6-18-6 + 155# N

Fertilization of Beet Crop:	102#	of N plowed down
	450#	60% potash plowed down
	400#	8-24-0 banded at planting time

Black Root Exposure: Slight

Leaf Spot Exposure: Slight

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seedbed. Generally good growing conditions throughout the season.

Reliability of Test: Fair

Cooperator: F. and M. Beet Sugar Association, Buckeye Sugar, Incorporated. Year: 1961

Location: Louis Risser farm, Pandora, Ohio. Expt: 2

(Results given as 8 plot averages)

Variety and Description		Acre-Yield: Gross Sugar	Acre-Yield: Roots	Sucrose	Purity	Beets per 100' of row
		Pounds	Tons	Percent	Percent	Number
S.P.6045-0	(mm)	5214	16.01	16.29	81.46	90
S.P.60194-01	(mm)	5661	16.84	16.81	82.97	101
S.P.60195-01	(mm)	5633	16.62	16.93	82.61	99
S.P.60196-01	(mm)	5581	16.29	17.14	83.28	106
S.L.122MS X E.L.42	(Mm)	6000	18.05	16.64	82.81	102
NB 1 X E.L.42	(MM)	6282	19.18	16.39	82.35	102
S.L.122MS X 5640-0	(Mm)	5532	16.53	16.72	83.11	110
S.P.5481-0	(MM)	6253	19.27	16.23	82.13	107
General Mean		5770	17.35	16.64	82.59	102
S.E. Var. Mean		148.5	.4884	.1849	.4268	3.8
S.E. Var. Mean as % Gen. Mean		2.57	2.81	1.11	0.52	3.73
Diff. for Sig. (odds 19:1)		424	1.39	0.53	NS	11

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	7	287,167	1.444	378	1.565	51
Between columns	7	795,553	4.871	728	5.668	606
Between varieties	7	1,120,406	13.589	776	3.222	300
Remainder - Error	42	176,476	1.908	273	1.457	116
Total	63					
Calculated F. value	7/42	6.35**	7.12**	2.84*	NS	2.59**

AGRONOMIC EVALUATION TEST, 1961

Conducted by: R. C. Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: K. Krauss Farm, Findlay, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 5, 1961

Date of Harvest: October 31, 1961

Experimental Design: Triple Lattice

Size of Plots: 6 rows x 22 feet planted (28 inch rows)

Harvest Area per Plot for Root Yield: 6 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for harvest stand. No bolters developed.

Recent Field History: Red Clover Sod

Fertilization of Beet Crop: 600 lbs. 10-20-10 per acre plowed down
175 lbs. 6-24-12 per acre in row

Leaf Spot Exposure: Moderate, rather late development

Black Root Exposure: Moderate

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia caused some loss in stand

Soil and Seasonal Conditions: Normal growing conditions prevailed throughout the growing season.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: K. Krauss Farm, Findlay, Ohio Year: 1961

(Results given as 6 plot averages)

Variety	Acre Yield: Sugar: Recoverable[a] (lbs.)	Acre Yield: Sugar: Gross (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d] Oct. 16	Beets[e] per 100 ft. (No.)
SP5822-0	6426	7518	23.06	16.30	92.85	1.2	95
US401	6306	7439	22.75	16.35	92.48	3.2	114
SP60194-01	6137	7232	21.85	16.55	92.53	2.2	121
SP5510-0	6051	7217	22.11	16.32	92.00	2.5	113
SP60195-01	5983	7062	21.08	16.75	92.43	1.8	119
SP60196-01	5879	6879	20.45	16.82	92.82	2.5	117
SP5481-0	5839	6951	21.23	16.37	92.08	2.2	113
SL122MS x SP5460-0	5273	6229	19.55	15.93	92.45	4.0	102
SP6045-0	5127	6114	19.25	15.88	92.03	3.5	106
General Mean[f]	5816	6874	20.97	16.39	92.40	2.6	111
S.E. Variety Mean(Sm)	-	193.53	.4694	.2794	.5380	-	-
Sm/Gen. M. (%)	-	2.81	2.24	1.71	0.58	-	-
LSD 5% pt.	544[b]	643	1.37	0.79	1.52	-	-

Variance Table[c]

Source of Variation	DF	Mean Squares: Roots (tons)	Mean Squares: Sucrose (%)	Mean Squares: Purity (%)
Replicates	5	4.4458	1.7480	4.4620
Component (a)	9	2.2171	.6644	1.2656
Component (b)	9	1.4760	.2578	.5167
Blocks (eliminating varieties)	18	1.8466	.4611	.8911
Varieties (ignoring blocks)	15	7.5719	.5553	1.7620
Error (Intra-block)	57	1.3216[g]	.4709	2.0030
Error (Random Block)	75	1.4477	.4685[g]	1.7361[g]
Total	95	2.5725	.5496	1.8837
Calculated F Value		5.23**	NS	NS

(a, (b, (c See Page 112
(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot
(e Harvest stand
(f General mean for 16 varieties in test
(g Error term used

AGRONOMIC EVALUATION TEST, 1961

Conducted by: R. C. Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glenn Haas Farm, Fremont, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 25, 1961

Date of Harvest: November 7, 1961

Experimental Design: Triple Lattice

Size of Plots: 6 rows x 22 feet planted (30 inch rows)

Harvest Area per Plot for Root Yield: 6 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for harvest stand. No bolters developed.

Recent Field History: Soybeans in 1960, fall planted to rye and spring plowed

Fertilization of Beet Crop: 525 lbs. 12-12-12 per acre
70 lbs. 46% treble superphosphate per acre
Both fertilizers disced into soil before planting

Leaf Spot Exposure: None

Black Root Exposure: Very severe

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia caused some loss in stand

Soil and Seasonal Conditions: Soil moisture and temperature conditions were very conducive to black root following planting. Remainder of the season was normal.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glenn Haas Farm, Fremont, Ohio Year: 1961

(Results given as 9 plot averages)

Variety	Acre Yield Sugar Recoverable[a] (lbs.)	Acre Yield Sugar Gross (lbs.)	Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Beets[e] per 100 ft. (No.)
SP5510-0	3596	4395	13.83	15.89	90.98	85
SP5822-0	3542	4179	13.24	15.78	92.50	80
SP5481-0	3338	3937	12.35	15.94	92.52	95
US401	3334	4105	12.95	15.85	90.68	87
SP60194-01	3294	3914	12.24	15.99	92.19	88
SP60196-01	3190	3707	11.65	15.91	93.19	88
SP6045-0	3078	3734	11.67	16.00	91.30	84
SP60195-01	2971	3620	11.44	15.82	91.11	85
SL122MS x SP5460-0	2905	3495	11.21	15.59	91.66	88
General Mean[f]	3206	3835	12.03	15.94	91.90	85
S.E. Variety Mean(Sm)	-	157.47	.5838	.1709	.4460	-
Sm/Gen. M (%)	-	4.11	3.96	1.07	0.49	-
LSD 5% pt.	446[b]	534	1.63	0.49	1.25	-

Variance Table[c]

Source of Variance	DF	Mean Squares Roots (tons)	Mean Squares Sucrose (%)	Mean Squares Purity (%)
Replicates	8	9.6187	.6363	1.6500
Component (a)	18	2.0048	.4339	1.7206
Component (b)	9	1.9335	.1878	1.4922
Blocks (eliminating varieties)	27	1.9811	.3519	1.6444
Varieties (ignoring blocks)	15	6.1261	.5227	4.7227
Error (Intra-block)	93	2.0627	.2629[g]	1.8330
Error (Random Block)	120	2.0443[g]	.2829	1.7906[g]
Total	143	2.8961	.3278	2.0903
Calculated F Value		3.00**	1.99*	2.64**

(a, (b, (c See Page 112
(e Harvest stand
(f General mean for 16 varieties in test
(g Error term used

AGRONOMIC EVALUATION TEST, 1961

Conducted by: R. C. Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 25, 1961

Date of Harvest: November 8, 1961

Experimental Design: Randomized Complete Block

Size of Plots: 3 rows x 22 feet planted (30 inch rows)

Harvest Area per Plot for Root Yield: 3 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for harvest stand. No bolters developed.

Recent Field History: Soybeans in 1960, fall planted to rye and spring plowed

Fertilization of Beet Crop: 525 lbs. 12-12-12 per acre
70 lbs. 46% treble superphosphate per acre
Both fertilizers disced into the soil before planting

Leaf Spot Exposure: None

Black Root Exposure: Very severe

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia caused some loss in stand.

Soil and Seasonal Conditions: Soil moisture and temperature conditions were very conducive to black root following planting. Remainder of the season was normal.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio   Year: 1961

(Results given [redacted] 6 plot averages)

Variety	Acre Yield: Sugar: Recoverable[a] (lbs.)	Acre Yield: Sugar: Gross (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Beets[e] per 100 ft. (No.)
SP6059-0	3673	4298	13.33	16.12	92.87	90
SP5481-0	3161	3674	11.39	16.13	93.18	92
SP5937-0	2897	3399	10.51	16.17	92.75	70
General Mean[f]	3362	3946	12.12	16.28	92.70	83
S.E. Variety Mean(Sm)	-	243.50	.7194	.2738	.4993	-
Sm/Gen. M. (%)	-	6.17	5.94	1.68	0.54	-
LSD 5% pt.	595[b]	699	2.07	0.79	1.43	-

Variance Table[c]

Source of Variance	DF	Mean Squares: Roots (tons)	Mean Squares: Sucrose (%)	Mean Squares: Purity (%)
Replicates	5	6.2126	.5240	2.4500
Varieties	7	7.7434	.3957	1.7400
Error	35	3.1036	.4497	1.4949
Total	47	4.1254	.4481	1.6330
Calculated F Value		2.50*	NS	NS

(a, (b, (c See Page 112
(e Harvest stand
(f General mean for 8 varieties included in test

AGRONOMIC EVALUATION TEST, 1961

Conducted by: R. C. Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Paul Wise Farm, Old Fort, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 13, 1961

Date of Harvest: November 1, 1961

Experimental Design: Randomized Complete Block

Size of Plots: 3 rows x 22 feet planted (30 inch rows)

Harvest Area per Plot for Root Yield: 3 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for harvest stand. No bolters developed.

Recent Field History: Corn

Fertilization of Beet Crop: 800 lbs. 12-12-12 plowed down in spring
200 lbs. 4-16-16 in row
15 ton per acre manure applied before plowing

Leaf Spot Exposure: Severe, rather late development

Black Root Exposure: Moderate

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia caused some loss in stand

Soil and Seasonal Conditions: Normal growing conditions prevailed throughout the summer.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Paul Wise Farm, Old Fort, Ohio Year: 1961

(Results given as 6 plot averages)

Variety	Acre Yield Sugar Recoverable[a] (lbs.)	Acre Yield Sugar Gross (lbs.)	Acre Yield Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d] Sept.18	Leaf Spot[d] Oct.19	Beets[e] per 100 ft. (No.)
SP6059-0	5544	6539	21.84	14.97	92.57	2.0	4.2	129
SP5481-0	5107	6119	20.56	14.88	91.88	2.0	4.2	126
SP5937-0	3975	4839	16.55	14.62	91.23	2.7	5.0	117
General Mean[f]	5082	6027	19.93	15.10	92.28	2.0	4.2	126
S.E. Variety Mean(Sm)	-	241.60	.7186	.2639	.4220	-	-	-
Sm/Gen. M (%)	-	4.01	3.61	1.75	0.46	-	-	-
LSD 5% pt.	584[b]	694	2.06	0.76	1.21	-	-	-

Variance Table[c]

Source of Variance	DF	Mean Squares Roots (tons)	Mean Squares Sucrose (%)	Mean Squares Purity (%)
Replicates	5	.9005	.2820	.5140
Varieties	7	4.0471	2.4200	3.2443
Error	35	1.7598	.4177	1.0683
Total	47	2.1981	.7015	1.3334
Calculated F Value		5.29*	5.79**	3.04*

(a, (b, (c See Page 112

(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot

(e Harvest stand

(f General mean for 8 varieties included in test

LEAF SPOT READINGS,* 1961
OBSERVATION TEST, PAUL WISE FARM, OLD FORT, OHIO

	Sept. 18	Oct. 6	
US401	3.0	5.7	9
SP5481-0	2.0	4.0	3
SP5510-0	2.0	4.3	6
SP5822-0	1.0	3.0	1
SP60194-01 (mm)	1.7	4.3	6
SP60195-01 (mm)	1.3	3.3	2
SP60196-01 (mm)	2.0	4.3	6
SL122 x SP5460-0 (mm)	3.0	5.0	8
SP6045-0 (mm)	2.0	5.0	8

* Average of 3 replications

(a **Recoverable Sugar** [1]

A technique, whereby thin juice purity could be determined from small samples was first used in 1953, following methods developed in the G. W. Research Laboratory at Denver. Using the resultant purity figure, a calculated "Recoverable Sugar" is obtained. An example of the calculation is as follows:

Sugar in beets = 12.00%
Standard total losses = 0.30%
Sugar on beets at sugar end = 12.00 - 0.30 = 11.70%

Assume standard molasses purity = 62.5%
100.0 - 62.5 = 37.5% Impurities on solids in molasses

$\frac{62.5}{37.5}$ = 1.6667% Sugar on impurities in molasses

Sugar sacked
85% purity thin juice = 15% impurities

$\frac{15}{85}$ = 17.6471% impurities on sugar

Sugar end = 11.70 x 17.6471% = 2.06471% on beets
Molasses produced = 2.06471 x 1.66667 = 3.4413% on beets
Sugar sacked = 12.00 - (0.30 + 3.4413) = 8.2587%

$$\text{Recoverable sugar} = \frac{8.2587}{12.00} = 68.82\%$$

(b **Approximation** - Calculated as percentage of "difference required for significance for "gross" sugar on basis of relationship between general means for "Gross" and "Recoverable" sugar.

(c **Gross sugar calculated from the formula:**

$$S \text{ lbs. sugar} = \text{Mean lbs. sugar} \sqrt{\left(\frac{S \text{ lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{S \text{ \% sugar}}{\text{Mean \% sugar}}\right)^2}$$

[1] This technique applies to experiments on pages 104, 106, 108, and 110.

AGRONOMIC EVALUATION TEST - 1961

Conducted by: C. E. Broadwell

Location: C. & D. Sugar Co., Ltd. Dover farm

Cooperation: Canada & Dominion Sugar Co., Ltd.

Date of Planting: May 18, 1961

Date of Harvest: October 18, 1961

Experimental Design: 8 x 8 Latin Square, Design #8

Size of Plots: 6 rows x 28 feet, 24 inches between rows, planted with Planet Jr.

Harvested Area per Plot for Root Yield: 4 rows x 28 feet, hand topped

Samples for Sucrose Determination: 4 samples of 5 beets each from each plot, selected at random.

Stand Counts: Harvested beets counted when weighed

Recent Field History: Corn

Fertilization of Beet Crop: 500# 5-20-10 banded

Blackroot Exposure: Some

Leaf Spot Exposure: In various degrees

Other Diseases and Pests: None

Soil and Seasonal Conditions: Dry and a little rough when planted. Good moisture throughout the year.

Reliability of Test: Fairly good

Cooperator: Canada and Dominion Sugar Company, Limited. Year: 1961

Location: C. and D. Sugar Company, Limited. Dover farm (Near Chatham, Ontario.)
Expt: 8

(Results given as 8 plot averages)

Variety and Description		Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
		Pounds	Tons	Percent	Percent	Number
S.P.6045-0	(mm)	4726	15.58	15.16		80
S.P.60194-01	(mm)	5243	16.94	15.45		84
S.P.60195-01	(mm)	5272	16.77	15.73		83
S.P.60196-01	(mm)	5004	16.03	15.63		84
S.L.122MS X E.L.42	(Mm)	5096	16.72	15.29		71
NB 1 X E.L.42	(MM)	5382	17.27	15.59		72
S.L.122MS X 5460-0	(Mm)	4545	14.85	15.31		73
S.P.5481-0	(MM)	5330	17.22	15.50		79
General Mean		5075	16.42	15.46		78
S.E. Var. Mean		149.4	.4839	.1059		3.1
S.E. Var. Mean as % Gen. Mean		2.94	2.95	0.68		3.97
Diff. for Sig. (odds 19:1)		426	0.14	0.30		9

Latin Square Analysis

Variance Table

Source of Variation	D/F	Mean Squares Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	7	763,523	8.903	283		63
Between columns	7	450,447	5.990	303		202
Between varieties	7	725,517	5.964	362		222
Remainder - Error	42	178,505	1.873	90		77
Total	63					
Calculated F. value	7/42	4.06**	3.18**	4.04**		2.86*

WESTERN ONTARIO AGRICULTURAL SCHOOL

AGRONOMIC EVALUATION TEST

1961

Conducted by - W.W.Snow

Location - Western Ontario Agricultural School, Ridgetown, Ont.

Date of Planting - May 5, 1961

Date of Harvest - October 11, 1961

Experimental Design - 8 varieties, 8 replications Latin Square

Size of Plots - 20 feet long, 24 inch rows, 3 row plots, planted with cone seeder.

Harvested Area per Plot for Root Yield - 3 rows x 14 feet; hand harvested and topped.

Samples for Sucrose Determination - 2 samples of 5 beets each from plot, selected at random

Stand Counts - Harvested beets counted when weighed

Recent Field History - Oats

Fertilization of Beet Crop - 60 lbs. N; 120 lbs. P_2O_5; 120 lbs. K_2O.

Black Root Exposure - none

Leaf Spot Exposure - Moderate

Other Diseases and Pests - none

Soil and Seasonal Conditions - Moist

Reliability of Test - Excellent

SUGAR BEET VARIETY TRIAL

W.O.A.S. 1961
+ + + + + + +

STRAIN	CERCOSPORA RATING	NO.ROOTS/100' OF ROW	% SUGAR (AVE.)	YIELD,LBS./AC. SUGAR (AVE.)	YIELD,TONS/ACRE ROOTS (AVE.)
1. S.P.6045-0	5	92.6	14.6	6012	20.6
2. S.P.60194-01	3	91.9	15.4	7373	23.9
3. S.P.60195-01	3	91.4	15.5	7056	22.8
4. S.P.60196-01	4	93.1	15.1	6361	21.1
5. S.L.122 x EL.42	5	85.4	15.5	6669	21.5
6. NB 1 x EL.42	3	88.3	15.3	7424	24.3
7. S.L.122 x S.P.5460-0	7	89.3	15.4	6607	21.5
8. S.P. 5481	4	85.4	15.7	7053	22.5

Data and calculations furnished by courtesy of
Western Ontario Agricultural School
Ridgetown, Ontario

L.S.D. at 0.05 level 1.6
L.S.D. at 0.01 level 2.1

C.V. 3.5 %

Cooperator: Michigan Agricultural Experiment Station-Farm Crops Dept. Year: 1961

Location: M. S. U. farm, East Lansing, Michigan, North Nursery. Expt: 11

5 x 6 Rectangular Lattice Design - 6 repl. - Analyzed as Randomized Block

(Results given as 6 plot averages)

Variety and Description	Acre-Yields Gross Sugar Pounds	Acre-Yields Roots Tons	Sucrose Percent	Purity Percent	Beets per 100' of row Number	leaf spot rating	Blackroot Rating
WC 0465	3034	12.29	12.33	80.27	87	3.2	
WC 0463	1734	10.44	8.16	73.81	88	5.0	
S.P.6059-0	2902	12.76	11.29	80.74	87	3.3	100
S.P.5937-0	3055	12.54	12.08	80.76	88	3.5	
9921H2	2702	13.00	10.29	77.46	84	4.8	
9921H1	2310	11.88	9.60	78.36	78	6.0	
S.P.6046-01	3063	13.06	11.69	80.64	88	4.0	
S.P.6046-02	3238	12.43	12.99	81.40	85	3.3	91
S.P.6047-01	3071	13.41	11.41	79.69	83	4.5	
S.P.6047-02	2784	11.51	11.97	80.74	84	4.0	
S.P.6048-01	2679	12.47	10.73	81.38	93	4.8	
S.P.6048-02	2288	10.74	10.35	79.16	95	4.2	
S.P.6049-01	3428	13.96	12.18	80.74	89	4.3	
S.P.60106-01	2781	11.49	12.05	79.64	85	4.0	
S.P.60109-01	2685	11.27	11.73	80.44	85	4.0	
S.P.60113-01	2863	12.52	11.45	79.41	87	4.2	
S.P.60114-01	2462	10.99	11.08	79.37	89	3.8	
S.P.60115-01	2731	12.24	11.14	78.10	91	4.2	
S.P.603103-01	2544	10.58	12.07	80.65	80	3.3	
S.P.60G18X03	2715	13.82	9.60	79.53	90	4.3	
S.P.60G19X03	3029	14.11	10.82	79.86	83	4.2	
S.P.60G20X03	3249	14.78	10.98	80.23	89	4.2	
S.P.60G22X03	3465	15.77	10.97	79.24	95	4.3	
S.P.60G24X03	2448	14.00	8.67	75.10	87	4.3	
S.P.60G25X03	2130	9.00	11.75	81.63	79	4.5	
S.L.122 X S.P.5460-0	2527	11.00	11.48	80.73	83	4.3	
S.P.59B18-0	4119	16.27	12.64	81.06	85	2.8	
S.P.56AB1-45	3855	14.46	13.16	82.58	93	2.8	
S.P.5481-0	3109	12.88	11.73	80.38	86	3.7	
S.P.59B18-01	3831	15.03	12.78	80.70	91	3.0	
General Mean	2894	12.69	11.30	79.79	87	4.0	
S.E. Var. Mean	248.6	.5348	.7102	1.391	3.1	0.06	
S.E. Var. Mean as % Gen. Mean	8.59	4.21	6.28	1.65	3.56	1.42	
Diff. for Sig. (odds 19:1)	696	1.50	1.99	3.69	9	0.2	

Random Block Analysis

Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row	Leaf Spot
Between replications	5	1,994,396	8.936	11.874	26.886	281	.40
Between varieties	29	1,617,853	16.844	8.325	19.552	109	2.21
Remainder - Error	145	370,874	1.716	3.027	10.443	58	.19
Total	179						
Calculated F. value	29/145	4.39**	9.81**	2.75**	1.87**	1.86**	11.45**

VARIETY TEST RESULTS - DETROIT STAKE FARM - 1961

Due to the poor germination and resultant non-uniform stands, the yield data has been adjusted to compensate for the poor stands. The average weight per beet of each entry was calculated from the harvest data. Previous work has shown that yield is not materially affected by stand until the stand drops below 60%. Where the individual plot stands were less than 60% (65 beets per harvested area per plot) the plot weights have been adjusted upward using the average weight per beet and 60% stand.

Entry No.	Description	Beets/Plot (Adjusted)	Tons/Acre (Adjusted)	% Sucrose	% Purity
1	Incr.of 59E5-0	71	10.9		
2	Incr.of 591103-0 (PI254575)	66	11.5		
3	BRR-LSR Syn. (8 clones)	69	10.9		
4	BRR-LSR Syn. (8 clones)	66	12.2		
5	(MS of NBI x NB4)xH3611 4N	71	13.5	14.5	81.13
6	(MS of NBI x NB3)xH3611 4N	78	11.3	14.4	83.22
7	SL 122 MS x 573040-0	75	12.6	15.1	83.05
8	SL 122 x US 401 4N	68	11.6	14.5	83.65
9	SL 122 x US 401 2N	69	12.5	14.8	84.08
10	SL 122 x MM inbred line (6052-01)	76	12.3	15.3	84.64
11	F_3mm of BRR-LSRmm x CTR-LSRmm	69	10.3		
12	" " " "	65	10.7		
13	" " " "	66	10.0		
14	" " " "	66	10.5		
15	" " " "	71	11.2		
16	C361HO x $S_3$09-5-13-4	79	13.0	15.0	85.39
17	C361HO x $S_3$09-5-9-9	72	12.1	14.2	83.03
18	C361HO x $S_3$09-5-16-14	78	12.5	14.6	82.96
19	C361HO x $S_3$09-5-9-19	74	12.0	14.0	80.75
20	C361HO x $S_3$09-5-7-32	65	12.7	13.7	81.54
21	C361HO x $S_3$09-7-32-40	65	11.6		
22	SL 122 MS x 5460-0	65	11.7	16.1	85.64
23	020000 x Polycross	78	11.6		
24	Incr.of 7 clones of US 401	76	11.5		
25	SP 5481-0	76	11.9		

The sucrose percentage figures are averages of 2 or 3 plots (two samples per plot).

16	C36180 x 5309-5-13-4	79	
17	C36180 x 5309-5-9-9	75	
18	C36180 x 5309-5-16-14	78	
19		74	
22	SL 122 MS x 5460-0	65	
23	070000 x Polyploid	76	
24	Incr. of 7 clones -- US 401	76	11.5
25	SP 5481-	75	11.9

The sucrose percentage figures are averages of 2 or 3 plots (two samples per plot).

The unadjusted data for stand and yield is shown below:

Entry No.	Beets Per Plot	Tons Per Acre	
1	60	9.1	
2	66	10.9	
3	66	10.4	6054-0
4	53	10.0	
5	69	12.0	
6	78	11.3	
7	73	12.3	
8	62	10.4	
9	56	10.1	
10	71	11.6	
11	65	9.7	
12	49	8.1	
13	51	7.7	
14	54	8.5	
15	60	9.5	
16	70	11.6	
17	77	12.0	
18	76	12.3	
19	70	11.4	
20	56	10.5	
21	52	9.2	
22	63	10.4	
23	77	11.4	
24	73	11.1	
25	76	11.7	

Effects of Leaf Spot on Soluble Solids
Experiment 11, MSU Farm, 1961

Effect of time of infection with leaf spot on the water soluble solids in the sugar beet at harvest time. The (1) samples were taken from the 2nd row of the 8 row plot and the (2) samples were taken from the 6th row of the plots. The 1st and 2nd row of the plots were inoculated August 1, whereas the remaining rows were infected by natural spread of the disease from the inoculated rows. We estimate a 3 week differential in time of infection between the two samples. Leaf spot readings were made Sept. 29. Each plot was given an overall rating and then the sample (1) and (2) rows were individually rated. Results are given as 6 plot averages.

Seed Number	Leaf Spot Rating			% Sucrose		% non-sugar solids	
	Plot	(1)	(2)	(1)	(2)	(1)	(2)
SP 56AB1-45	2.8	3.5	2.3	13.3	13.1*	2.63	2.90
SP 59B18-0	2.8	3.5	2.5	12.5	12.8	2.72	3.23
SP 59B18-01	3.0	3.7	2.3	12.3	13.2	2.97	3.12
WC 0465 (59E5-0)	3.2	4.0	3.0	11.9	12.8	3.16	2.85*
SP 6046-02	3.3	3.8	3.0	12.8	13.2	3.04	2.87*
SP 603103-01	3.3	3.8	3.0	12.2	11.9*	2.82	2.93
SP 6059-0	3.3	4.0	3.2	10.3	12.3	2.41	2.78
SP 5937-0	3.5	4.2	3.3	11.2	13.0	2.71	2.88
SP 5481-0	3.7	4.2	3.3	10.6	12.8	2.73	2.67*
SP 60114-01	3.8	4.2	3.5	11.0	11.1	3.00	2.73*
SP 60106-01	4.0	4.5	3.8	11.7	12.4	2.89	3.24
SP 6047-02	4.0	4.0	4.0	11.2	12.7	2.77	2.88
SP 6046-01	4.0	4.2	3.7	10.8	12.6	2.67	2.90
SP 60109-01	4.0	4.3	3.7	11.7	11.8	2.94	2.76*
SP 60113-01	4.2	4.3	4.0	10.9	12.0	3.07	2.87*
SP 60115-01	4.2	4.3	3.8	11.0	11.3	2.99	3.25
SP 60G20X03	4.2	4.3	4.0	10.6	11.3	2.80	2.58*
SP 60G19X03	4.2	4.2	4.0	10.5	11.2	2.73	2.60*
SP 6048-02	4.2	4.3	4.0	9.9	10.8	2.49	2.81
SP 6049-01	4.3	4.3	3.8	11.8	12.6	2.93	2.74*
SL 122 X SP 5460-0	4.3	4.8	4.2	11.3	11.7	2.73	2.71*
SP 60G22X03	4.3	4.3	4.2	10.8	11.2	2.64	3.11
SP 60G18X03	4.3	4.2	4.0	9.4	9.8	2.21	2.47
SP 60G24X03	4.3	4.3	4.2	8.2	9.2	2.52	2.78
SP 60G25X03	4.5	4.5	4.2	11.5	12.0	2.71	2.50*
SP 6047-01	4.5	4.5	4.2	10.6	12.2	2.78	2.90
SP 6048-01	4.8	5.0	4.3	10.1	11.4	2.36	2.54
9921 H2	4.8	5.0	4.7	9.8	10.8	2.63	3.36
9921 H1	5.0	5.0	5.0	9.8	9.4*	2.72	2.43*
WC 0463 (PI254575)	5.0	5.2	4.8	6.7	9.7	2.70	2.54*
Average	4.0	4.3	3.7	10.87	11.74	2.75	2.83

* deviation from the general trend

(See next page)

(cont.)

Effects of Leaf Spot on Soluble Solids

General Mean	4.01	11.30	2.79
S.E. var mean	.2345	.6745	.1480
S.E. var mean as % Gen. $\bar{X}$	5.85	5.96	5.30
Diff. for Sig.(19:1)	0.7	1.89	0.41

Random Block Analysis — Variance table

Source of Variation	D/F	Mean Squares: L.S. Rating	Mean Squares: % Sucrose	Mean Squares: % non-sugar solids
Replications	5	0.200	24.152	.6747
Samples (rows)	1	27.000	67.520	.6325
Variety	29	3.448	16.701	.4080
Var. x Repl.	145	0.255	6.040	.2628
Var. x Samples	29	0.345	1.831	.2165
Repl. x Samples	5	0.400	1.682	.1785
V. x S. x R.	145	0.400	1.106	.1755
(pooled)wo/V xR	179		1.239	.1822
(pooled)all inter	324	0.330		
Total	359			
Calculated F value				
Varieties		10.45**	2.76**	1.55**
Samples		81.82**	54.48**	3.47NS

PART V

DEVELOPMENT AND EVALUATION
of
SUGARBEET BREEDING MATERIAL AND VARIETIES CARRYING RESISTANCE TO LEAF SPOT AND CURLY TOP

Foundation Projects 25 and 26

J. O. Gaskill
G. E. Coe
J. C. Overpeck
A. M. Murphy

Cooperators conducting tests:

Colorado Agricultural Experiment Station
National Sugar Manufacturing Company
New Mexico Agricultural Experiment Station

DEVELOPMENT AND TESTING OF SUGARBEET LINES AND VARIETIES HAVING RESISTANCE TO BOTH LEAF SPOT AND CURLY TOP, 1961 1/

(A phase of Beet Sugar Development Foundation Project No. 25)

John O. Gaskill 2/

Breeding

Because of the continuing threat of both leaf spot and curly top to the sugarbeet crop in certain areas east of the Rocky Mountains, increased attention was given in 1961 to the need for productive varieties with combined resistance to both diseases. At Ft. Collins, increased emphasis was placed on the relatively new, long-term project of developing monogerm, type-O, inbred lines (and their male-sterile equivalents) with resistance to both leaf spot and curly top and with high sucrose and good combining ability. Inbred lines with similar qualities but lacking the type-O and male-sterility characters also are being sought. In this breeding project, extensive use is being made of curly top resistant material developed by other U.S. Department of Agriculture stations, especially at Salt Lake City, Utah. US 201 is being used as a major source of genes for leaf spot resistance. Other U.S.D.A. leaf spot resistant lines are being used to some extent for that purpose; also highly resistant introductions of Beta maritima. The monogerm gene stemming initially from the Savitsky discovery

1/ This progress report pertains only to breeding and testing work conducted at Ft. Collins, Colorado, and to cooperative tests conducted at other locations, by various investigators, with results summarized at the Ft. Collins station. The work at Ft. Collins was performed in cooperation with Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and Board of County Commissioners of Larimer County, and was supported in part by funds contributed by the National Sugar Manufacturing Co.

2/ Plant Pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

(SL 101) is serving as the principal source of monogermness, but Russian and Polish monogerm introductions also are being used. It is anticipated that some of the lines resulting from this breeding project will be suitable for use in the production of commercial monogerm hybrids and that some will be of value primarily as gene sources for use by other breeders.

Cooperative Evaluation Tests

Six varieties, resulting from the work of several breeders and having a background of selection for both leaf spot and curly top resistance, were included in a cooperative testing program in 1961 together with a productive curly top resistant, multigerm hybrid and a commercial monogerm hybrid serving as standards. The 8 varieties are described in an accompanying table. Agronomic (Latin-Square, 8x8) evaluation tests were conducted at the following locations by the indicated organizations: Crowley, Colorado (National Sugar Manufacturing Co.); Leoti, Kansas (National Sugar Manufacturing Co. and the Tribune Branch Station of Kansas Agricultural Experiment Station); Ft. Collins, Colorado (U. S. Department of Agriculture). Observational tests for leaf spot and curly top resistance were conducted by the U.S. Department of Agriculture at Beltsville, Maryland, and Jerome, Idaho, respectively. Stand in the Leoti test was quite variable, largely as a result of hail and crust early in the season. The results from that test are considered decidedly unreliable and are not included in this report. Results from the other 4 tests are presented in 3 tables.

The leaf spot readings at Ft. Collins and Beltsville and the curly top data obtained at Jerome show that substantial progress has been made

in combining resistance to both diseases. The outstanding variety in this respect (#5, SP 6051-0) rather closely approaches the curly top resistant standard (#7, SL 202 H9) in resistance to curly top. However, the leaf spot resistance of SP 6051-0 is less impressive, particularly when comparison is made with the highly resistant inbred line, US 201, under the very severe leaf spot exposure at Beltsville.

For varietal comparisons in yield and sucrose percentage, under severe leaf spot exposure, the results presented for Ft. Collins experiment no. 1A are considered reliable. Such varietal comparisons, for conditions of mild or negligible leaf spot exposure, may be made in the results shown for the Crowley test. However, because of erratic stand losses due to Rhizoctonia root rot, the results from that test must be used with much caution. The relatively satisfactory yield and sucrose capabilities shown for variety #3 (SLC 122 MS x SP 5460-0) in the Ft. Collins and Crowley tests are of special interest because of the wide-spread commercial use of that variety in certain other sugarbeet growing areas and because of the fact that it is a monogerm hybrid combining moderate resistance to both leaf spot and curly top.

Other Tests at Ft. Collins

Other tests under leaf spot conditions at Ft. Collins, involving material having resistance to both leaf spot and curly top, included the following: (a) an agronomic evaluation test of 14 varieties (exp. 9A), and (b) an observational test of leaf spot resistance (exp. 5A). A summary of results for each of those tests is presented.

COOPERATIVE EVALUATION TESTS OF LSR-CTR VARIETIES, 1961

Description of Varieties

Entry no.	Ft. Collins seed no.	Description
1	Acc. 2270	LSR-CTR; monogerm hybrid; SLC 122 MS mm x SP 5651. Supplied by Utah-Idaho Sugar Company as U-I No. R-5651.
2	Acc. 2271	LSR-CTR; monogerm hybrid; SLC 122 MS mm x ((SLC 114 x 601) x U-I 13). Supplied by Utah-Idaho Sugar Company as U-I No. R/13.
3	Acc. 2286	LSR-CTR; monogerm hybrid; SLC 122 MS mm x SP 5460-0. Supplied by Farmers and Manufacturers Beet Sugar Association as Lot No. 1055.
4	Acc. 2274	LSR-CTR; monogerm variety; SP 60100-00. Supplied by Dr. G. E. Coe, U.S.D.A., Beltsville, Maryland.
5	Acc. 2273	LSR-CTR; multigerm variety; SP 6051-0. Supplied by Dr. G. E. Coe.
6	SP 581813-00	LSR-CTR; multigerm variety; developed at Fort Collins by backcrossing, using CTR varieties as the recurring parental type.
7	Acc. 2272	CTR; multigerm hybrid; CT9 MS hybrid x US 22/3. Supplied by Dr. F. V. Owen as SL No. 202 H9.
8	Acc. 2383	Commercial monogerm hybrid, NHM-2; "local check". Furnished by National Sugar Manufacturing Company.

AGRONOMIC EVALUATION TEST OF LSR-CTR VARIETIES, 1961
Experiment No. 1A, Fort Collins, Colorado

Conducted by: J. A. Elder and J. O. Gaskill

Location: Hospital Farm, Ft. Collins, Colorado; field no. 2.

Cooperation: Colorado Agricultural Experiment Station, National Sugar Manufacturing Company, Beet Sugar Development Foundation, and Board of County Commissioners of Larimer County.

Dates of Planting and Harvest: April 25-26; Oct. 10.

Experimental Design: Latin Square, 8x8; plots 4 rows x 24'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in the 2 inner rows x 21' in each plot were hand topped, washed, and weighed.

Determination of Sucrose Percentage: All roots harvested for root yield determination in each plot were divided into 2 samples for sucrose analyses. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand Counts: All hills in the 2 inner rows x 21' in each plot were counted on September 15. No bolters were observed.

Recent Cropping History: 1958 and 1959, alfalfa; 1960, barley.

Chemicals Applied for Sugarbeet Crop: Treble superphosphate (approximately 280 lbs. per acre) and ammonium nitrate (approximately 93 lbs. per acre) were applied in August, 1960, just before plowing. Shell DD (about 45 gal. per acre) was applied in September, 1960, for sugarbeet nematode control.

Leaf Spot Exposure: Severe

Sugarbeet Nematode: Mild

Other Diseases and Pests: Negligible

Soil and Seasonal Conditions: The weather was much wetter than usual throughout most of the growing season. Furrow irrigation was adequate. Inoculation and frequent sprinkling were employed in order to promote the development of leaf spot (*Cercospora beticola*).

Reliability of Test: Good

AGRONOMIC EVALUATION TEST OF LSR-CTR VARIETIES, 1961
Experiment No. 1A, Fort Collins, Colorado
(Results given as 8-plot averages)

Description	F. C. seed no.	Entry no.	Acre yield: Gross sucr.	Acre yield: Roots	Sucrose	Leaf spot a/ 8/21	Leaf spot a/ 8/31	Leaf spot a/ 9/11	Fol. b/ vig. 8/31	Stand (hills per 100')
			Lbs.	Tons	%					No.
SLC 122 MS x SP 5651; mono.	Acc. 2270	1	2388	8.48	14.10	4.2	4.8	4.9	4.4	120.3
SLC 122 MS x ((SLC 114 x 601) x U-I 13); mono.	" 2271	2	2452	8.58	14.28	4.2	4.9	4.9	4.8	113.3
SLC 122 MS x SP 5460-0; mono.	" 2286	3	2670	9.32	14.32	4.0	4.4	4.3	5.0	114.5
SP 60100-00; mono.	" 2274	4	2477	8.77	14.13	3.0	3.9	3.9	4.5	112.6
SP 6051-0; multi.	" 2273	5	2704	9.33	14.50	2.4	3.4	3.3	5.0	113.5
Multi.	SP 581813-00	6	2663	9.15	14.55	2.0	2.8	2.6	5.1	112.1
SL 202 H9; multi.; CTR check	Acc. 2272	7	2501	10.04	12.45	4.9	5.1	5.1	4.4	114.8
NHM-2; mono.; local check	" 2383	8	2391	8.52	14.03	4.9	5.0	5.1	4.3	116.3
General mean			2530.70	9.0219	14.0442					114.66
S. E. of var. mean			60.78	0.2113	0.0966					2.146
S. E. of var. mean as % of gen. mean			2.40	2.34	0.69					1.87
L. S. D. (5% point)			173	0.60	0.28					6.1

Variance Table

Source of Variation	D/F	Mean Square (Variance): Gross sucr.	Roots	Sucrose %	Stand
Rows	7	89,173.7	0.8708	0.3806	165.24
Columns	7	29,805.4	0.2342	0.2049	45.46
Varieties	7	133,656.3	2.3336	3.6153	54.53
Error (remainder)	42	29,555.7	0.3573	0.0747	36.85
Total	63				
Calculated F value		4.52**	6.53**	48.40**	1.43

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation
b/ Foliage vigor: larger no. = greater vigor

OBSERVATIONAL TESTS OF LSR-CTR VARIETIES, 1961
Beltsville, Maryland, and Jerome, Idaho

Description	F. C. seed no.	Entry no.	Beltsville a/ Leaf spot grade 8/1	Beltsville a/ Leaf spot grade 8/12	Jerome (curly top) b/ Planted 5/16 % C. T. 7/20	Planted 5/16 % C. T. 8/10	Planted 5/16 C.T. grade 8/29	Planted 5/25 % C. T. 7/28	Planted 5/25 % C. T. 8/18	Planted 5/25 C. T. grade 8/29
US 33; mod. CTR var.; multi. (ck.)	—	—	—	—	58.0	89.8	5	93.8	95.5	7
SLC 122 MS x SP 5651; mono.	Acc. 2270	1	4.8	5.8	28.6	47.6	4	56.2	95.8	5
SLC 122 MS x ((SLC 114x601) x U-I 13); mono.	" 2271	2	4.3	5.8	27.9	49.0	4	47.2	86.6	5
SLC 122 MS x SP 5460-0; mono.	" 2286	3	4.8	5.8	45.4	71.8	5	56.1	86.6	6
SP 60100-00; mono.	" 2274	4	4.4	5.0	53.5	68.4	5	81.1	96.4	6
SP 6051-0; multi.	" 2273	5	3.1	4.6	38.2	51.5	4**	43.8	59.2	4
Multi.	SP 581313-00	6	3.1	4.4	53.8	91.0	5	52.6	94.7	6
SL 202 H9; multi.	Acc. 2272	7	5.1	5.9	10.2	25.4	4	9.7	27.2	3
NHM-2; mono.	" 2383	8	5.1	6.0	26.2	53.2	4	32.1	58.2	5
US 33; mod. CTR var.; multi (ck.)	—	—	—	—	48.1	96.2	6	93.5	96.8	7
US 201; LSR inbred; multi. (ck.)	—	—	2.0	2.0	—	—	—	—	—	—
US 401; LS-BR res. var.; multi. (ck.)	—	—	3.9	5.0	—	—	—	—	—	—

a/ The test at Beltsville, Maryland, was conducted by G.E.Coe, U.S.D.A. Results are given as 2-plot averages (each plot 4 rows wide). Basis of leaf spot grades: 0 = no leaf spot; 10 = complete defoliation due to leaf spot.

b/ The test at Jerome, Idaho, was conducted by Albert M. Murphy, U.S.D.A. Results are based on a single plot (2 rows x 50') for each date of planting. Basis of curly top grades: 0 = healthy; 9 = death due to curly top. **- Good vigor.

AGRONOMIC EVALUATION TEST OF LSR-CTR VARIETIES, 1961
Crowley, Colorado

Conducted by: Loyd Dillon

Location: Farm operated by Walter Bronner, about 1 mile north and 1/2 mile west of Crowley, Colorado.

Cooperation: National Sugar Manufacturing Company

Dates of Planting and Harvest: April 12; October 21

Experimental Design: Latin Square, 8x8; plots 6 rows x 30'; rows 22" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in 2 rows x 30' in each plot were topped, washed, and weighed.

Determination of Sucrose Percentage: Two composite sugar samples per plot

Leaf Spot Exposure: Very mild

Rhizoctonia Root Rot: Rhizoctonia root rot caused substantial, erratic stand losses throughout much of the test area during the latter part of the growing season.

Other Diseases and Pests: Negligible

Soil and Seasonal Conditions: Soil fertility was considered satisfactory and furrow irrigation was adequate.

Reliability of Test: The crop apparently developed normally throughout the season except for stand losses due to Rhizoctonia root rot. Effects of those losses are reflected in the relatively large L.S.D. values, especially for yield of roots and gross sucrose. The results obtained from this test must be used very cautiously.

AGRONOMIC EVALUATION TEST OF LSR-CTR VARIETIES, 1961
Crowley, Colorado
(Results given as 8-plot averages)

Description	F. C. seed no.	Entry no.	Acre Yield: Gross sucrose	Acre Yield: Roots	Sucrose
			Lbs.	Tons	%
SLC 122 MS x SP 5651; mono.	Acc. 2270	1	3251 8	11.96	13.49 7
SLC 122 MS x ((SLC 114x601) x U-I 13); mono.	" 2271	2	3592 5	12.50	14.25 4
SLC 122 MS x SP 5460-0; mono.	" 2286	3	4027 4	14.17	14.03 5
SP 60100-00; mono.	" 2274	4	4201 2	14.42	14.55 2
SP 6051-0; multi.	" 2273	5	3270 7	11.47	13.95 6
Multi.	SP 581813-00	6	4150 3	14.28	14.56 1
SL 202 H9; multi.; CTR check	Acc. 2272	7	4241 1	16.03	13.16 8
NHM-2; mono.; local check	" 2383	8	3578 6	12.44	14.34 3
General mean			3788.72	13.4075	14.0406
S. E. of var. mean			233.68	0.7196	0.3135
S. E. of var. mean as % of gen. mean			6.17	5.37	2.23
L. S. D. (5% point)			667	2.05	0.89

Variance Table

Source of variation	D/F	Mean square (variance): Gross sucrose	Mean square (variance): Roots	Mean square (variance): Sucrose %
Rows	7	2,954,701.9	24.2200	3.3443
Columns	7	1,279,324.4	10.4652	1.9786
Varieties	7	1,374,441.0	19.2963	1.9986
Error (remainder)	42	436,861.0	4.1426	0.7862
Total	63			
Calculated F value		3.15**	4.66**	2.54*

AGRONOMIC EVALUATION TEST OF MISCELLANEOUS VARIETIES, 1961
Experiment No. 9A, Fort Collins, Colorado

Conducted by: J. A. Elder and J. O. Gaskill

Location: Hospital Farm, Ft. Collins, Colorado; field no. 2.

Cooperation: Colorado Agricultural Experiment Station, National Sugar Manufacturing Company, Beet Sugar Development Foundation, and Board of County Commissioners of Larimer County.

Dates of Planting and Harvest: April 26-27; Oct. 10-11.

Experimental Design: Equalized-Random-Block, 14x7; plots 3 rows x 24'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root yield: All roots in the center row x 21' in each plot were hand topped, washed and weighed.

Determination of Sucrose Percentage: All roots harvested for root yield determination in each plot constituted one sample for sucrose analysis. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand Counts: All hills in the center row x 21' in each plot were counted on September 18. No bolters were observed.

Recent Cropping History: 1958 and 1959, alfalfa; 1960, barley.

Chemicals Applied for Sugarbeet Crop: Treble superphosphate (approximately 280 lbs. per acre) and ammonium nitrate (approximately 93 lbs. per acre) were applied in August, 1960, just before plowing. Shell DD (about 45 gal. per acre) was applied in September, 1960, for sugarbeet nematode control.

Leaf Spot Exposure: Severe

Sugarbeet Nematode: Mild

Other Diseases and Pests: Negligible

Soil and Seasonal Conditions: The weather was much wetter than usual throughout most of the growing season. Furrow irrigation was adequate. Inoculation and frequent sprinkling were employed in order to promote the development of leaf spot (*Cercospora beticola*).

Reliability of Test: Satisfactory

AGRONOMIC EVALUATION TEST OF MISCELLANEOUS VARIETIES, 1961
Experiment No. 9A, Fort Collins, Colorado
(Results given as 7-plot averages)

Description	F. C. seed no.	Entry no.	Acre yield: Gross sucr.	Acre yield: Roots	Sucrose	Leaf spot a/: 8/21	Leaf spot a/: 8/31-9/1	Leaf spot a/: 9/11	Fol. b/ vig.: 8/31-9/1	Stand: (hills per 100')
			Lbs.	Tons	%					No.
LS-BR-Bot. res. syn. var.; mm; SP 591101-0	SP 601000-0	851	2571	8.99	14.30	2.0	2.8	2.9	5.3	104.9
do	SP 601153H0	852	2706	9.40	14.35	1.5	2.2	2.4	5.6	107.0
SP 581220-2 MS mm ♀ x SP 591101-0 mm	SP 601153H01	853	2955	10.02	14.72	2.1	3.1	2.7	5.0	104.9
SP 571702-01 MS mm ♀ x P.I. 254575 (Rus. mm)	SP 591200H01	854	2753	9.80	14.04	2.3	3.3	3.5	5.9	101.3
SP 571702-01 MS mm ♀ x P.I. 254576 (Rus. mm)	SP 591201H01	855	3036	10.47	14.46	2.4	3.5	3.4	5.7	106.1
SLC 122 MS mm x SP 5460-0 MM; lot 1055	Acc. 2286	856	2742	9.81	13.99	3.6	4.4	4.4	5.0	103.4
SP 5832-0; SP 5935-0; WC 0465; mm	" 2329	857	2632	9.32	13.99	1.9	2.9	3.0	5.6	101.4
SP 5481-0; EL 1023; MM	" 2231	858	2788	9.79	14.24	2.0	2.9	2.9	5.4	101.4
SL 202H9; CT9 MS hyb. x US 22/3; MM	" 2272	859	2611	10.77	12.10	4.9	5.2	5.3	4.0	101.3
9921H1; (MS of NB1 x NB3) x H3611; M	" 2327	860	3151	11.53	13.66	3.4	4.5	4.4	4.7	102.0
9921H2; (MS of NB1 x NB4) x H3611; M	" 2328	861	3116	11.64	13.37	3.6	4.6	4.9	5.0	104.1
063H1; US H2; MM	" 2384	862	2782	10.55	13.15	4.4	5.1	5.4	4.4	102.0
063H2; US H6; MM	" 2385	863	2534	9.84	12.86	4.6	5.3	5.6	4.0	100.7
GW 674-56C; MM; local check	" 2168	864	3120	10.78	14.49	1.9	3.3	3.9	6.1	104.6
General mean			2821.33	10.1940	13.8378					103.22
S. E. of var. mean			119.42	0.3749	0.1585					2.653
S. E. of var. mean as % of gen. mean			4.23	3.68	1.15					2.57
L. S. D. (5% point)			337	1.06	0.45					7.5

Variance Table

Source of Variation	D/F	Mean Square (Variance): Gross sucr.	Roots	Sucrose %	Stand
Rows	6	182,512.3	1.9962	0.4317	318.51
Columns	6	392,479.8	3.3200	0.5497	19.51
Varieties	13	323,572.8	4.4451	3.7782	29.11
Error (remainder)	72	99,836.9	0.9840	0.1758	49.28
Total	97				
Calculated F value		3.24**	4.52**	21.49**	0.59

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation
b/ Foliage vigor: larger no. = greater vigor

OBSERVATIONAL TEST OF MISCELLANEOUS MATERIAL
Leaf Spot Sprinkler Field, Hospital Farm, Fort Collins, Colorado
Experiment No. 5A, 1961
(Conducted by J. A. Elder and J. O. Gaskill)

Description or source	Immed. parent or contrib. no.	F. C. seed no.	Entry no.	Leaf spot a/ 8/22	Leaf spot a/ 9/1	Fol. b/ vig. 9/5	No. of plots
CLR (Poland); MM	Acc. 2210	SP 601001-0	721	1.8	2.8	6.0	3
rryy ♀ x rrYy; MM	SP 581814-02	SP 601002-0	722	4.5	5.0	4.5	2
SP 5-273-0; CTR syn.; MM	SP 8-1906-0	SP 601003-0	723	4.8	5.0	4.5	2
SP 6-2007-0; LSR syn.; MM	SP 451058-0	SP 601004-0	724	3.3	3.5	4.5	2
Synthetic Check; Acc. 1055; MM	SP 451069-0	SP 601005-0	725	4.2	4.3	4.3	3
Synthetic Check; SP 451069-0; MM	WC 0464	Acc. 2269	726	3.8	4.7	4.7	3
Synthetic Check; SP 486-0; MM	WC 3216	" 1327	727	4.3	5.0	4.7	3
From SL 727 and SL 915; MM	SL 0410	" 2275	728	2.5	4.3	4.0	3
CTR sel. from US 201-B; MM	SL 727	" 2186	729	2.0	3.0	5.0	3
do	SL 915	" 2240	730	2.3	4.0	4.0	3
F_1, SL 727 sel. aa x SP 57109-0, etc; MM	SL 9401	" 2241	731	2.2	3.7	5.0	3
Increase of SL 9401; MM	SL 001	" 2276	732	2.0	2.8	5.0	3
US 201 x 201-B; CTR sel.; MM	SL 011	" 2277	733	2.2	3.5	4.7	3
US 201-B; CTR sel.; MM	SL 012	" 2278	734	2.3	4.0	4.3	3
N.M. CTR sel. from SP 57109-0; MM	SL 016	" 2279	735	2.3	3.0	5.3	3
SP 557 MS mm x US 201-B MM CTR sel.	SL 0140	" 2280	736	2.7	3.3	5.0	3
mm from L.C. 1959 selections	SL 0702 ⊗	" 2282	737	2.5	4.0	4.5	2
do	SL 0704 ⊗	" 2283	738	2.5	4.0	4.5	2
mm from CT5 and CT9	SL 0524	" 2284	739	6.0	6.3	3.7	3
Orig. SLC 122 mm	SL 6240	" 2386	740	3.3	4.3	5.0	3
SLC 122-19; sub-line of SLC 122; mm	SL 0529	" 2285	741	2.7	4.8	2.7	3
Orig. MS of SLC 122; mm	SL 6133	" 2387	742	4.2	5.0	4.3	3
P.I. 254575; SP 591103-0; Rus. mm	WC 0463	" 2330	743	2.8	4.0	5.3	3
Russian mm	P.I. 254575	SP 591000-0	744	3.0	4.5	5.0	3
Rus. "mm" (many doub. germ s.b.)	P.I. 254576	SP 591001-0	745	2.3	3.5	5.0	3
LSR-CTR; MM	SP 6051-0	Acc. 2331	746	2.0	2.5	5.3	3
LSR-CTR; mm	" 60103-01	" 2332	747	3.0	3.7	4.0	3
do	" 60104-01	" 2333	748	2.8	3.2	5.3	3
do	" 60105-01	" 2334	749	2.7	3.0	5.0	3
do	" 60106-01	" 2335	750	2.7	3.5	5.0	3
do	" 60107-01	" 2336	751	2.5	3.2	5.0	3
do	" 60108-01	" 2337	752	2.7	3.3	5.0	3
do	" 60109-01	" 2338	753	2.3	3.3	5.3	3
do	" 60110-01	" 2339	754	2.5	3.2	5.3	3
do	" 60111-01	" 2340	755	2.7	3.2	4.7	3
do	" 60112-01	" 2341	756	3.0	3.3	5.0	3
do	" 60113-01	" 2342	757	2.8	3.3	5.3	3
do	" 60114-01	" 2343	758	2.7	3.3	4.7	3
do	" 60115-01	" 2344	759	2.3	3.3	5.3	3
do	" 60116-01	" 2345	760	2.3	3.0	5.3	3
do	" 60117-01	" 2346	761	2.3	2.8	5.3	3
do	" 60118-01	" 2347	762	2.2	3.0	5.0	3
do	" 60119-01	" 2348	763	3.0	3.3	4.7	3
do	" 60120-01	" 2349	764	3.0	3.2	5.0	3
do	" 60121-01	" 2350	765	2.3	2.5	5.7	3
SP 5481-0; MM	SL-1023	2231	766	1.9	2.6	6.0	6
US 201; MM	SP 501007-0	SP 581001-0	767	1.0	1.3	5.2	6
US 22/4; MM	SL 92	Acc. 1363	768	4.6	4.6	4.8	6
LS-BR res. hyb.; MM	SP 59B18-0	" 2398	769	1.3	1.8	6.0	3

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation
b/ Foliage vigor: larger no. = greater vigor

Field Plan and Remarks: Plots 2 rows x 12'; rows 20" apart; replications as indicated. Artificial inoculation and frequent sprinkling were used to promote leaf spot development. Stand was satisfactory throughout, and results are considered reliable.

OBSERVATIONAL TEST OF BOLTING RESISTANT MALE STERILE LINES
Leaf Spot Sprinkler Field, Hospital Farm, Ft. Collins, Colo.
Experiment No. 8A, 1961
(Conducted by J.A. Elder and J.O. Gaskill)

Description a/ or source	Immed. parent or contributor's no.	F. C. seed no.	Entry no.	Leaf spot b/ 8/22	Leaf spot b/ 9/1	Fol. vig. c/ 9/5	No. of Plots
Male sterile lines:							
MS of NB1; M	F59-502 HO	Acc. 2388	871	6.0	6.7	3.7	3
MS of NB1 x NB3; M	F59-509 H1	" 2389	872	5.3	5.3	4.3	3
MS of NB1 x NB2; M	F59-511 H1	" 2390	873	5.0	5.7	5.0	3
MS of NB1 x NB4; M	F59-554 H1	" 2391	874	4.2	4.3	5.0	3
F58-515 HO x 7569; m	F59-569 H1	" 2392	875	4.8	5.7	3.7	3
MS of NB5 x NB6; M	F60-512 H1	" 2393	876	4.5	4.7	5.0	3
MS of NB1 x NB5; M	F60-547 H1	" 2394	877	4.0	4.2	5.3	3
F58-515 HO x 9561-4; m	F60-561 H1	" 2395	878	4.7	5.3	4.0	3
F59-569 HO x 8569; m	F60-569 HO	" 2396	879	5.3	6.0	4.0	3
9561 H2 x 9561-16; m	0562 HO	" 2397	880	4.2	5.3	4.0	3
Checks:							
SP 5481-0; LS-BR res. var;M	EL-1023	" 2231	881	1.7	2.4	6.0	6
US 201; LS res. inb.; M	SP 501007-0	SP 581001-0	882	1.0	1.3	5.3	3
US H2; bolt. res. hyb.; M	063 H1	Acc. 2384	883	3.7	3.7	5.0	3
US 75; bolt. res. var.; M	C368	" 2015	884	2.8	4.0	5.0	3

a/ Predominant type of seed planted in experiment 8A: M = multigerm; m = monogerm.

b/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation.

c/ Foliage vigor: Larger number = greater vigor.

Field Plan: Plots 2 rows x 12'; rows 20" apart; replications as indicated. Artificial inoculation and frequent sprinkling were employed to promote leaf spot development.

Remarks: Except for entry numbers 881 and 882, all seed was furnished by J. S. McFarlane, Crops Research Division, A.R.S., U.S.D.A., Salinas, California. Stand was satisfactory in all plots, and results are considered reliable.

PART VI

DEVELOPMENT OF BREEDING PROCEDURES
and
PRODUCTION OF BASIC BREEDING MATERIAL

Chemical Genetic Studies
and
Polyploidy Evaluation

Foundation Project 25

LeRoy Powers R. J. Hecker

Research conducted in cooperation with Colorado Agricultural Experiment Station.

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON THE GENETIC AND PLANT BREEDING PHASES OF PROJECT 25 1/

By LeRoy Powers and Richard J. Hecker

CHEMICAL GENETIC STUDIES INVOLVING THIRTEEN CHARACTERS IN SUGAR BEETS 2,3,4,5/

The increased use of nitrogen fertilizers in the production of sugar beets emphasizes the importance of chemical-genetic and soils studies pertaining to processing quality in sugar beets. Of particular interest are the interrelations of weight per root, percentage sucrose, and percentage apparent purity and chemical characters in the thin juice and in the petioles as influenced by certain fertilizer practices. The purpose of this article is to study the interrelations of the different characters. Some of the information has been reported in previous articles, Payne et al. (5,6) and Powers et al.(9,10,11).

1/ The breeding and genetic phases of Project 25 are cooperative with the Agronomy Department of the Colorado State University Agricultural Experiment Station.

2/ Cooperative investigations of the Colorado Agricultural Experiment Station; the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; and the Beet Sugar Development Foundation. The Colorado State University gratefully acknowledges financial support from the James G. Boswell Foundation administered by the Agricultural Research Center of Stanford Research Institute, the National Institutes of Health, and the Beet Sugar Development Foundation and contract-research-funds from the Agricultural Research Service of the U. S. Department of Agriculture. These studies would not have been possible if these funds had not been granted.

3/ The writers are indebted to R. Ralph Wood of the Great Western Sugar Company for obtaining thin juice samples by an oxalate method standard with his company and also acknowledge the cooperation of D. W. Robertson and Robert S. Whitney in conducting the field experiment. The writers are indebted to the Western Data Processing Center at the University of California at Los Angeles for use of the computing facilities for analyzing data.

4/ This portion of the report is being prepared for publication by LeRoy Powers, W. R. Schmehl, W. T. Federer, and Merle G. Payne.

5/ This portion of the report was prepared by LeRoy Powers.

Materials, Experimental Design, Methods, and Analyses

These studies were conducted during 1956 and 1958, and 1960 and 1961.

For 1956 the materials are populations A54-1, A54-1BB, 50-406BB, 50-406, F_1 hybrid, and 52-307. A54-1 is a commercial variety and A54-1BB resulted from seed harvested from 25 mother beets of A54-1. The 25 mother beets giving rise to population A54-1BB were grown in an isolated seed plot along with 25 mother beets from each of 22 other populations. Seed was harvested from all mother beets on an individual plant basis and seed from each mother beet of A54-1 was bulked to produce the seed for population A54-1BB. Seed saved from mother beets of 50-406 and handled in a similar manner produced the population designated as 50-406BB. Hence, 50-406BB is a top-cross hybrid. Populations 50-406 and 52-307 are inbreds and the F_1 hybrid population resulted from crossing them.

For 1958 the populations were A56-5BB, A56-5BB_1, A54-1, 52-430, F_1 hybrid, and 55-5307. A56-5BB is the population produced from the seed of 120 mother beets of A56-5 surrounded by mother beets from A54-1, AC No. 2, MW 391, US 201, SL 028, and Janascz. A54-1 is a commercial variety, 52-430 and 55-5307 are inbred lines, and the F_1 hybrid resulted from crossing these two inbreds. Since 50-406 and 52-430 have green hypocotyls and the inbreds 52-307 and 55-5307 have red hypocotyls the hybrid populations for both 1956 and 1958 were obtained by leaving only red hypocotyl beets during thinning. The same was true for 1960 and 1961. For 1960 the populations are three F_1 hybrids and A56-3 and for 1961 the populations are an F_1 hybrid and A56-3.

For 1956 there were two treatments, non-fertilized and fertilized. The fertilized plots received a surface application of 100 pounds of N and 250 pounds of P_2O_5 per acre on April 4, 1956. The fertilizer was cultivated under with a rototiller. The experiment was planted on April 10 and 11. On June 26, another 100 pounds of N per acre were drilled in the center of each space between rows of the fertilized plots.

For 1958, 250 pounds of P_2O_5 were applied to all plots on April 3 and disked deeply into the soil. On March 4, 50 pounds of N were applied to all plots and harrowed under. On March 8 an additional 100 pounds of N were applied to one-third of the plots and 250 pounds to another one-third

of the plots. This made three applications of nitrogen: 50 pounds, 150 pounds, and 300 pounds per acre.

For 1960 and 1961, 100 pounds of N and 250 pounds of P_2O_5 per acre were applied on the entire experimental area.

Experimental Design

The sources of variation and number of items for 1956 are shown in table 1. There are 40 replications. Treatments are a split plot of replications; the two treatments in 1956 and the three treatments in 1958 are randomized within each replication. The six populations are randomized within each treatment and the eight locations are within each plot of each population. The plots were single rows.

Table 1. Sources of variation designated as main effects, and number of each, 1956.

Main effects	Number
Replications	40
Populations	6
Treatments	2
Locations	8

In 1956 and 1961 every plot was bordered by a row of A54-1 to provide uniform competition. After thinning, each plot had 12 plants in 1956 and 24 plants in 1961. The stands remained excellent during the growing season. The rows were spaced 22 inches apart and in 1956 the plants were spaced 20 inches apart within the row and in 1961 they were spaced 10 inches apart within the row. In 1958 the rows were spaced 44 inches apart and the plants were thinned to 10-inch spacings within the row. In 1960 the rows were spaced 22 inches apart and the plants were thinned to 10-inch spacings within the row. In 1956 and 1958 data were taken on only eight plants, the extra plants at each end of the row being discarded at time of harvest. Selection was avoided during thinning by saving the plant farthest south in a blocked group.

In 1960 all the plants per plot were harvested. In 1961, 15 competitive plants per plot were harvested. The stands were excellent in all years.

The design of the experiment in 1960 was a randomized complete block with 30 replications and in 1961 a randomized complete block with 10 replications.

Purity, nitrogen, glutamic acid, betaine, and chlorides were determined from thin juice samples only, and are expressed as milligrams per 100 milliliters of thin juice equated to a refractometer reading of 10. Potassium and sodium were determined from both thin juice and petioles samples. In the thin juice they are expressed as parts per 100,000 and in the petioles as parts per million. Finally, nitrate nitrogen and phosphorus were determined only from petiole samples and are expressed as parts per million. For more details of the method used to determine total nitrogen see Payne et al (5). Standard methods were used in making the chemical determinations for the other characters (see Payne et al, 6). The methods used in analyzing the data are those given by Powers et al (9,10,11) and Federer et al (3). For the details of the methods of calculation the reader is referred to these articles. Primarily, the analyses were made by employing the analysis of variance, components of variance methods of genetic analysis, and regression. In this article the biology and not the statistical procedures will be emphasized.

Results

This article is concerned, primarily, with the interrelations of the characters as determined by a study of the means and simple correlation coefficients, with phenotypic-dominance phenomena, and dates of harvest and combining ability tests.

Means

The means will be studied first as the determination of phenotypic-dominance involves a comparison of the means. The means for populations within treatments for 1956 are listed in table 2.

Table 2. Means for populations within treatments, 1956.

Treatment and population	Weight1,2/	Sucrose1,2/	Thin juice1,2/ Purity	Nitro-gen	Glutamic acid	Betaine	Potas-sium	Sodium	Petioles3/ Nitrate N	Phos-phorus	Potas-sium	Sodium
	Lbs.	%	%	Mg.	Mg.	Mg.	Pp 100,000	Pp 100,000	Ppm	Ppm	Ppm	Ppm
Non-fertilized												
A54-1	1.93	17.9	96.1	18.8	12.8	89.8	122.6	27.0	1736	1793	29275	10940
A54-1BB	1.71	17.8	96.5	16.9	7.6	85.5	114.4	25.0	1592	1902	27160	11280
50-406BB	1.40	17.6	97.2	12.6	6.4	69.9	99.3	19.5	1491	1556	25505	8490
50-406	0.75	17.4	95.9	14.6	8.0	73.4	103.8	17.6	962	1388	23315	6875
F1	1.54	17.6	97.6	9.8	3.5	51.3	96.0	19.9	1284	1899	31665	9010
52-307	0.58	16.5	96.4	11.1	3.0	79.8	106.8	25.8	1253	2616	33520	10455
Fertilized												
A54-1	2.60	16.8	93.2	46.8	80.1	116.6	133.1	47.9	4233	1598	17695	15265
A54-1BB	2.64	16.7	93.0	44.8	41.4	115.1	129.7	49.6	4884	1628	18795	15050
50-406BB	2.04	17.3	94.4	33.6	45.8	106.1	112.5	31.5	4267	1335	17500	11460
50-406	1.02	16.1	92.6	31.2	17.3	125.3	122.6	33.4	2297	1362	17650	9570
F1	2.23	17.6	95.3	21.3	18.0	101.3	101.9	33.5	3060	1545	18595	10570
52-307	1.16	16.6	94.9	18.6	10.0	108.7	99.4	43.4	3644	2234	24690	14995
LSD at 5% level 4/	0.12	0.3	0.4	3.2	8.0	6.1	5.1	3.4	817	159	2020	1121
LSD at 5% level 5/	0.14	0.4	0.7	3.7	8.5	6.9	5.3	4.2				

1,2/ These least significant differences are calculated from individual plant data.
3/ These least significant differences are calculated from replications condensed to 10 groups.
4/ For comparing populations within treatments.
5/ For comparing treatments within populations.

Populations A54-1 and A54-1BB have the largest weights per root on both the non-fertilized and the fertilized plots. Also, these two populations have the highest percentage sucrose on the non-fertilized plots. This is not true of the fertilized plots as the F_1 and 50-406BB have the highest percentages sucrose. They are intermediate in weight per root. On the non-fertilized plots, the lowest weight per root and the lowest percentage sucrose occurs in population 52-307 and on the fertilized plots in population 50-406. Definitely, there is a genotype-environment interaction as regards the interrelation of weight per root and percentage sucrose. That higher weight per root and higher percentage sucrose can be combined is of economic importance. The F_1 and 50-406BB are highest in percentage apparent purity on the non-fertilized plots and the F_1, 52-307, and 50-406BB are highest in percentage apparent purity on the fertilized plots. It is interesting to note that both the F_1 and 50-406BB are hybrid populations, the F_1 being a single-cross hybrid and 50-406BB being a top-cross hybrid.

Total nitrogen in the thin juice is lowest for the F_1 and 52-307 and highest for A54-1 and A54-1BB. This is true of both the non-fertilized and fertilized plots. On the fertilized plots glutamic acid averages highest for A54-1 and lowest for 52-307, 50-406, and the F_1. A54-1 has more than twice as much total nitrogen as 52-307 and 8 times as much glutamic acid on the fertilized plots. A54-1BB and 50-406BB are intermediate in glutamic acid and do not differ significantly from each other. The F_1 is lowest in betaine on both the non-fertilized and fertilized plots. A54-1 and A54-1BB are highest in betaine on the non-fertilized plots and 52-307, 50-406, and 50-406BB are intermediate. On the fertilized plots 50-406 is highest in betaine and A54-1 and A54-1BB are next highest with 52-307 and 50-406BB having still lower betaine but having more betaine than the F_1 hybrid.

On the non-fertilized plots and for the thin juice the F_1 and 52-307 are lower in potassium than A54-1 and A54-1BB, but they are higher in potassium in the petioles. On the fertilized plots 52-307 is again lower than A54-1 in potassium in the thin juice but higher in potassium in the petioles. It is clear that comparative concentrations of potassium in the petioles are not necessarily indicative of the comparative concentrations of potassium in the thin juice. On the non-fertilized plots all but populations A54-1BB and 50-406BB and 52-307 and the F_1 differ significantly from each other as regards potassium in the petioles; whereas, on the fertilized plots only 52-307 differs significantly from the others. Such facts as these must be kept in mind when interpreting the genetic correlation coefficients which are presented later in this article.

Comparisons involving sodium in the thin juice and sodium in the petioles agree fairly well, both on the non-fertilized and fertilized plots. In these comparisons 50-406BB, 50-406, and the F_1 have low sodium and A54-1, A54-1BB, and 52-307 have high sodium. Population 50-406 has significantly lower sodium in the petioles than any other population with the possible

exception of the F_1 hybrid on the fertilized plots.

On the non-fertilized plots there are no statistically significant differences at the 5% level in the amounts of nitrate nitrogen in the petioles. On the fertilized plots 50-406 and the F_1 are lowest in nitrate nitrogen in the petioles, 52-307 is intermediate, and A54-1, A54-1BB, and 50-406BB are highest.

The comparisons between total nitrogen in the thin juice and nitrate nitrogen in the petioles for the two inbreds and their corresponding F_1 is informative. Populations 52-307 and the F_1 have lower total nitrogen than 50-406 in the thin juice and higher nitrate nitrogen in the petioles. The latter comparison between 52-307 and 50-406 on the fertilized plots is statistically significant at the 5-percent level. It is apparent that comparative amounts of nitrate nitrogen in the petioles cannot be taken as indicative of comparative amounts of total nitrogen in the thin juice.

Population 52-307 is highest in phosphorus on both the non-fertilized and fertilized plots, whereas 50-406 and 50-406BB are the lowest. Populations A54-1, A54-1BB, and the F_1 are intermediate and do not differ materially. These data were taken on the petiole samples. The comparisons are essentially the same for the non-fertilized and fertilized plots.

A comparison of the treatment means of table 2 reveals that for 1956, on the fertilized plots as compared with the non-fertilized plots there is an increase in weight per root, total nitrogen, glutamic acid, betaine, potassium in the thin juice, sodium in the thin juice and petioles and nitrate nitrogen. The same comparisons reveal that there is a decrease on the fertilized as compared with non-fertilized plots for percentage sucrose, percentage apparent purity, and phosphorus and potassium in the petioles. Potassium on an average is higher in the thin juice on the fertilized plots; whereas, the reverse is true for potassium in the petioles. It is clear that comparative concentrations of potassium in the thin juice cannot be taken as indicative of comparative concentrations of potassium in the petioles. Also, it should be noted that there is a genotype-environmental interaction as regards potassium. Population 52-307 is significantly lower in potassium in both the thin juice and petioles on the fertilized plots than on the non-fertilized plots, whereas all the other varieties have higher potassium in the thin juice on the fertilized plots as compared with the non-fertilized plots and lower potassium in the petioles of the fertilized plots as compared with the non-fertilized plots. This is an interaction involving genotype, fertilizer treatments, and location in the plant (tops or roots). This behavior would be expected if some populations retain greater amounts of potassium in the tops, whereas for other populations it is translocated to the roots, resulting in greater concentrations of potassium in the thin juice.

The 1958 means for populations within treatments are listed in table 3; and the means for populations over all treatments, in table 4; and the means for treatments over populations, in table 5.

Table 3. Means for populations and treatments, 1958.

Treatment and Population	Weight	Sucrose	Thin juice: Purity	Thin juice: Nitrogen	Thin juice: Glutamic acid	Thin juice: Betaine	Thin juice: Chlorides	Petioles: Nitrate N	Petioles: Phosphorus	Petioles: Potassium	Petioles: Sodium
	Lbs.	%	%	Mg.	Mg.	Mg.	Mg.	Ppm	Ppm	Ppm	Ppm
50 Lbs. N											
A56-5BB	2.52	13.4	89.5	57.2	44.2	121.3	3.14	3433	1400	33315	19095
A56-5BB$_1$	2.59	13.4	89.6	55.2	44.0	122.2	3.24	3724	1390	32055	19265
A54-1	2.99	14.6	89.2	62.9	72.0	154.9	3.12	2683	1318	27745	19430
52-430	1.39	14.4	89.4	63.1	49.4	169.1	2.73	1493	2018	19990	16135
F$_1$	2.32	13.9	89.7	59.3	54.8	151.5	2.19	2220	1380	17065	16890
55-5307	1.62	12.8	85.8	86.9	132.6	181.8	2.48	1392	1241	9870	21335
150 Lbs. N											
A56-5BB	2.58	13.0	87.4	70.6	75.0	133.2	2.35	5626	1348	30380	19095
A56-5BB$_1$	2.58	13.0	86.5	75.3	92.6	148.8	2.69	4726	1300	29540	19295
A54-1	2.84	14.0	86.4	79.7	115.2	166.5	2.52	4626	1261	22465	18310
52-430	1.37	14.0	87.0	68.9	67.8	199.1	2.41	2648	1651	15665	15845
F$_1$	2.21	13.7	87.9	76.0	93.8	158.4	1.83	3358	1269	14235	16970
55-5307	1.70	12.1	82.6	117.8	158.4	222.8	2.24	1929	1052	6560	17775
300 Lbs. N											
A56-5BB	2.58	12.1	84.0	85.7	108.0	142.5	2.65	9660	1239	27630	19605
A56-5BB$_1$	2.53	11.9	83.6	88.0	131.2	151.3	2.87	9262	1129	27750	19745
A54-1	3.03	13.0	82.7	103.5	158.4	190.4	2.36	7968	1238	21960	18115
52-430	1.29	13.4	85.0	89.5	95.6	214.0	2.47	5099	1486	14860	15030
F$_1$	2.32	13.0	84.8	102.0	132.2	177.2	1.82	6386	1045	14720	15225
55-5307	1.67	11.3	78.8	144.5	228.8	229.5	2.28	5274	886	9970	17205
LSD at 5% level 1/	0.21	0.4	0.7	8.3	25.5	17.7	0.32	885	200	1784	2249

1/ These LSD's are calculated from the replications condensed to 5 groups.

Table 4. Means for populations, average of 3 fertility treatments, 1958.

Populations	Weight	Sucrose	Thin juice					Petioles			
			Purity	Nitrogen	Glutamic acid	Betaine	Chlorides	Nitrate N	Phosphorus	Potassium	Sodium
	Lbs.	%	%	Mg.	Mg.	Mg.	Mg.	Ppm	Ppm	Ppm	Ppm
A56-5EB	2.56	12.8	87.0	71.2	75.7	132.3	2.71	6240	1329	30442	19265
A56-5EB$_1$	2.57	12.8	86.6	72.8	89.3	140.8	2.93	5904	1273	29782	19435
A54-1	2.95	13.9	86.1	82.0	115.2	170.6	2.67	5092	1272	24057	18618
52-430	1.35	13.9	87.1	73.8	70.9	194.1	2.54	3080	1718	16838	15670
F_1	2.28	13.5	87.5	79.1	93.6	162.4	1.95	3988	1231	15340	16362
55-5307	1.66	12.1	82.4	116.4	173.3	211.4	2.33	2865	1060	8800	18772
LSD at 5% level	0.12	0.2	0.4	4.8	14.7	10.2	0.18	511	115	1030	1298

Table 5. Means for treatments, averages of all populations, 1958.

Treatment	Weight	Sucrose	Thin Juice					Petioles			
			Purity	Nitrogen	Glutamic acid	Betaine	Chlorides	Nitrate N	Phosphorus	Potassium	Sodium
	Lbs.	%	%	Mg.	Mg.	Mg.	Mg.	Ppm	Ppm	Ppm	Ppm
50 Lbs. N	2.24	13.7	88.9	64.1	66.2	150.1	2.82	2491	1458	23340	18692
150 Lbs. N	2.21	13.3	86.3	81.4	100.5	171.4	2.34	3819	1313	19808	17882
300 Lbs. N	2.24	12.4	83.2	102.2	142.4	184.2	2.40	7275	1170	19482	17488
LSD at 5% level	0.08	0.2	0.3	3.4	10.4	7.2	0.13	361	81	728	918

Population A54-1 has the largest weight per root followed by A56-5BB$_1$ and A56-5BB. The F_1 hybrid is fourth in weight per root and 55-5307 and 52-430 fifth and sixth, respectively. Populations A54-1 and 52-430 average highest in percentage sucrose and the F_1 is third followed by A56-5BB and A56-5BB$_1$. Population 55-5307 is lowest in percentage sucrose. The F_1 is highest in apparent purity and 55-5307 is lowest. These data show that high weight per root and high percentage sucrose are not mutually exclusive as the highest percentages sucrose are for A54-1 and 52-430, the former having the largest weight per root and the latter having the smallest weight per root.

Population 55-5307 averages highest in total nitrogen and A54-1 and the F_1 are next highest. A56-5BB, A56-5BB$_1$, and 52-430 are lowest. Glutamic acid follows nearly the same pattern. Population 55-5307 is highest in betaine followed by 52-430 and A54-1. The F_1 is next in order of magnitude and A56-5BB and A56-5BB$_1$ are lowest.

The level of chlorides is low for all populations and the F_1 has the lowest chlorides of all populations. Population 55-5307 is next lowest followed in order by 52-430, A54-1, A56-5BB, and A56-5BB$_1$.

Populations 55-5307 and 52-430 are lowest in nitrate nitrogen in the petioles, whereas A56-5BB and A56-5BB$_1$ are highest. As regards phosphorus, population 55-5307 is lowest and 52-430 is highest. The F_1 and the other 3 populations do not differ materially as regards parts per million of phosphorus in the petioles. Population 55-5307 is lowest in potassium in the petioles, the F_1 and 52-430 are next lowest, A54-1 is intermediate, and A56-5BB and A56-5BB$_1$ are highest. Populations 52-430 and the F_1 are lowest in sodium, whereas the other four populations are not materially different.

The relations between total nitrogen and the nitrogenous compounds in the thin juice and nitrate nitrogen in the petioles is interesting. Population 55-5307 is materially higher than A56-5BB in total nitrogen, glutamic acid, and betaine in the thin juice and is decidedly lower than A56-5BB in nitrate nitrogen in the petioles. Further, population 55-5307 is materially higher than 52-430 in total nitrogen, glutamic acid, and betaine in the thin juice but does not differ materially from 52-430 as regards nitrate nitrogen in the petioles. These findings make it clear that the comparative amounts of nitrate nitrogen in the petioles cannot be taken as an indication of the comparative amounts of total nitrogen and nitrogenous compounds in the thin juice.

The treatment means for each population in 1958 are listed in table 3 and the treatment means averaged over all populations in table 5. It is clear from a study of these two tables that the weights per root do not differ materially with the amounts of nitrogen added as fertilizer. However, there is a decrease in percentage sucrose, percentage apparent

purity, phosphorus, potassium, and sodium with an increase in the amounts of nitrogen applied as fertilizer. Also, as might be expected, there is an increase in total nitrogen, glutamic acid, betaine, and nitrate nitrogen with an increase in amounts of nitrogen applied as fertilizer.

One interaction of table 3 involving total nitrogen in the thin juice is particularly interesting. At the 50 pounds application of nitrogen, total nitrogen in the thin juice, percentage sucrose, and percentage apparent purity are not significantly different for populations A54-1 and 52-430. At 150 pounds application of nitrogen, A54-1 compared with 52-430 is significantly higher in total nitrogen in the thin juice, has the same percentage sucrose, and approaches statistical significance in having lower percentage apparent purity. At the 300 pounds application of nitrogen, A54-1 compared with 52-430 is significantly higher in total nitrogen and significantly lower in both percentage sucrose and percentage purity. This confirms the findings for 1956 that genotypes differ in the concentrations of nitrogen in the thin juice grown under identical applications of fertilizer and that total nitrogen in the thin juice is negatively associated with percentage sucrose and percentage apparent purity.

Three interactions in table 4 are of particular interest. First, the F_1 is significantly higher than A56-5BB$_1$ in total nitrogen in the thin juice, percentage sucrose, and percentage apparent purity. This shows that some genotypes may have higher nitrogen in the thin juice than other genotypes and at the same time have higher percentages of sucrose and purity. The second interaction involves genotypes and total nitrogen in the thin juice as compared to nitrate nitrogen in the petioles. Population 55-5307 has the highest concentration for any population of total nitrogen in the thin juice and the lowest concentration for any population of nitrate nitrogen in the petioles, whereas A56-5BB has the lowest concentration for any population of total nitrogen in the thin juice and the highest concentration for any population of nitrate nitrogen in the petioles. It is evident that concentrations of nitrate nitrogen in the petioles cannot always be taken as a reliable indicator of comparative concentrations of total nitrogen in the thin juice. These first two interactions confirm findings for the 1956 data. Finally, 52-430 compared with the F_1 has a significantly higher concentration of betaine in the thin juice, has significantly higher sucrose, and is significantly lower in percentage purity.

Phenotypic Dominance

Phenotypic-dominance phenomena derived from a comparison of the means of the inbreds and their corresponding F_1 hybrids (see tables 2, 3 and 4) are listed in tables 6 and 7. The terms used in classifying the dominance phenomena are heterosis+, dominance+, partial dominance+, intermediate, partial dominance-, dominance-, and heterosis-. A plus following the designation indicates that the greater expression of the character exhibits the

phenomenon tabulated. A minus following the designation indicates the smaller expression of the character exhibits the phenomenon listed. Heterosis is used when the expression of the character goes beyond that of either parent, dominance when the character is not significantly different from one or the other parent, partial dominance when the expression of the character lies between the two parents but closer to the mean of one of the parents, and intermediate when the expression of the character is not significantly different from the mean of the two parents.

Table 6. Phenotypic dominance for weight per root and chemical characters in the thin juice and in the petioles of the sugar beet; comparisons involve the inbreds and F_1 of 50-406 and 52-307, 1956.

Material and character	Non-fertilized[1,2]	Fertilized[1,2]
Weight per root	Heterosis+	Heterosis+
Sucrose	Heterosis+	Heterosis+
Thin juice		
Purity	Heterosis+	Heterosis+
Nitrogen	Heterosis-	Partial dominance-
Glutamic acid	Dominance-	Dominance+
Betaine	Heterosis-	Heterosis-
Potassium	Heterosis-	Dominance-
Sodium	Partial dominance-	Dominance-
Petioles		
Nitrate nitrogen	Dominance+	Intermediate
Phosphorus	Partial dominance-	Partial dominance-
Potassium	Partial dominance+	Partial dominance-
Sodium	Partial dominance+	Partial dominance-

1/ A plus following the designation shows that the greater expression of the character shows either partial dominance, dominance, or heterosis.

2/ A minus following the designation shows that the lesser expression of the character shows either partial dominance, dominance, or heterosis.

Table 7. Phenotypic dominance for weight per root and chemical characters in the thin juice and in the petioles of the sugar beet; comparisons involve the inbreds and F_1 of 52-430 and 55-5307, 1958, averages for the three levels of nitrogen application.

Material and character	Average[1,2]
Weight per root	Heterosis+
Sucrose	Partial dominance+
Thin juice	
Purity	Dominance+
Nitrogen	Partial dominance-
Glutamic acid	Partial dominance-
Betaine	Heterosis-
Chlorides	Heterosis-
Petioles	
Nitrate nitrogen	Heterosis+
Phosphorus	Partial dominance-
Potassium	Partial dominance+
Sodium	Partial dominance-

1/ A plus following the designation shows that the greater expression of the character shows either partial dominance, dominance, or heterosis.

2/ A minus following the designation shows that the lesser expression of the character shows either partial dominance, dominance, or heterosis.

The data for 1956 are for the inbreds and the F_1 hybrid 50-406 X 52-307.

As would be expected, weight per root exhibits heterosis in a plus direction on both the fertilized and non-fertilized plots. Likewise, percentage sucrose and percentage apparent purity exhibit plus heterosis on both the non-fertilized and fertilized plots.

Considering the thin juice samples, total nitrogen exhibits minus heterosis on the non-fertilized plots and minus partial dominance on the fertilized plots. Glutamic acid exhibits minus dominance on the non-fertilized plots and plus dominance on the fertilized plots. However, the differences on the non-fertilized plots are not significant at the 5% level. This behavior indicates a genotype-environment interaction involving comparisons between the two inbreds and the F_1. Betaine exhibits minus heterosis on both the non-fertilized and the fertilized plots. Potassium exhibits minus heterosis on the non-fertilized plots and minus dominance on the fertilized plots. Sodium exhibits minus partial dominance on the non-fertilized plots and minus dominance on the fertilized plots. Again the difference between the low sodium parent and the F_1, is not significant at the 5% level.

Turning to a consideration of the chemical characters taken on the petioles, nitrate nitrogen exhibits plus dominance on the non-fertilized plots and intermediate dominance on the fertilized plots. Phosphorus exhibits minus partial dominance on both the non-fertilized plots and the fertilized plots. Both potassium and sodium exhibit plus partial dominance on the non-fertilized plots and minus partial dominance on the fertilized plots. These are genotype-environment interactions and they are well established statistically.

The phenotypic-dominance phenomena for 1958 are tabulated in table 7. Comparisons involve the inbreds and F_1 derived from crossing 52-430 and 55-5307.

Again weight per root exhibits plus heterosis, as was expected. Percentage sucrose exhibits plus partial dominance and percentage apparent purity exhibits plus dominance. Nitrogen and glutamic acid exhibit minus partial dominance and betaine and chlorides exhibit minus heterosis. The latter four characters are from thin juice samples, as were the data for purity.

Again nitrate nitrogen, phosphorus, potassium and sodium were determined from petiole samples. Nitrate nitrogen showed plus heterosis; phosphorus, minus partial dominance; potassium, plus partial dominance; and sodium, minus partial dominance.

The phenotypic-dominance phenomena tabulated in tables 6 and 7 are of interest to the beet sugar industry, even though in these two tables only two F_1 hybrids and their corresponding inbred parents are involved. The main characters are weight per root, percentage sucrose, and percentage

apparent purity. In the F_1 of 50-406 X 52-307, all of these three characters exhibited heterosis. As previously pointed out this was to be expected for weight per root. The fact that percentage sucrose and percentage apparent purity also exhibit heterosis indicates that hybrids or at least some form of breeding utilizing heterosis will play a dominant role in the production of sugar from beets. Also it is significant that in the thin juice nitrogen, betaine, potassium, and sodium exhibited minus partial dominance, minus heterosis, and minus dominance, respectively, on the fertilized plots. On the non-fertilized plots these four characters and glutamic acid showed minus reactions. Such behavior would lead to comparatively smaller amounts of these chemicals in the thin juice. Such reactions in turn would be expected to result in higher percentages sucrose and purities. Therefore from this behavior of some of the impurities in the thin juice, plus heterosis for percentage apparent purity might have been anticipated.

Correlation Coefficients

The relations noted between characters in tables 2-5, inclusive, and table 8 can be expressed as correlation coefficients. The simple correlation coefficients express average relations between two characters; that is, measure the average association between two characters. It is important that this be kept in mind while interpreting the data, especially when associations differ materially depending upon the environment, genotype, location in the plant, or all three. It is equally important to keep in mind the limitations of the data. For example, the data of table 8 include only two years and five fertilizer treatments. This is a small sample of years and fertilizer treatments. Likewise, the number of populations studied are eleven for the two years 1956 and 1958. Such being the case, when interactions are involved, it is necessary to study in detail the data in tables 2-5, inclusive, and table 8 in order to make correct deductions.

As is the case with the variances, the covariances can be divided into that portion attributable primarily to differences in the environment and that attributable primarily to genotypic differences. In these studies the environmental variances include a negligible amount of genetic variance and the genetic variances include a negligible amount of environmental variability. The environmental correlation coefficients will be considered first.

Table 8. Means for treatments, within years, five levels of total nitrogen in the thin juice, 1956 and 1958 population A54-1.

Year and treatment	Weight	Sucrose	Thin juice							Petioles			
			Purity	Nitro-gen	Glutamic acid	Betaine	Chlor-ides	Potas-sium	Sodium	Nitrate N	Phos-phorus	Potas-sium	Sodium
	Lbs.	%	%	Mg.	Mg.	Mg.	Mg.	Pp 100,000	Pp 100,000	Ppm	Ppm	Ppm	Ppm
1956													
Non-fertilized	1.93	17.9	96.1	18.8	12.8	89.8		122.6	27.0	1736	1798	29275	10940
Fertilized	2.60	16.8	93.2	46.8	80.1	116.6		133.1	47.9	4233	1598	17695	15265
1958													
50 lbs. N	2.99	14.6	89.2	62.9	72.0	154.9	3.12			2683	1318	27745	19430
150 lbs. N	2.84	14.0	86.4	79.7	115.2	166.5	2.52			4626	1261	22465	18310
300 lbs. N	3.03	13.0	82.7	103.5	158.4	190.4	2.36			7968	1238	21960	18115
LSD 1/	0.14	0.4	0.7	3.7	8.5	6.9		5.3	4.2	817	159	2020	1121
LSD 2/	0.21	0.4	0.7	8.3	25.5	17.7	0.32			885	200	1784	2249

1/ LSD at 5% level, 1956.

2/ LSD at 5% level, 1958.

Environmental variability

The means for treatments within years at five levels of total nitrogen in the thin juice for 1956 and 1958 and for population A54-1 are given in table 8. These data permit a study of the interrelations of characters under partially controlled environmental conditions. Fertilizer practices were controlled within each year. As can be seen from an examination of table 8 there were five levels of total nitrogen in the thin juice starting with the non-fertilized plots in 1956 and progressing to the 300-pound application of nitrogen in 1958. These five levels of total nitrogen in the thin juice resulted from applications of known amounts of N and from possible year effects. Known amounts of P_2O_5 were added to the fertilized plots in 1956, and to all of the plots in 1958. It should be noted that the data in table 8 are only for population A54-1 and,hence, genetic differences due to populations are non-existent. Simple correlation coefficients were calculated yielding constants which show the average relations between the characters.

A study of the means listed in table 8 shows that the decreases in percentages sucrose and apparent purity, starting with the non-fertilized plots in 1956 and progressing to the 300-pound application of N in 1958, were accompanied by an increase in total nitrogen, glutamic acid and betaine in the thin juice. In 1956 potassium and sodium in the thin juice increased also. As published in a previous article,nitrogen, glutamic acid and betaine are highly associated as regards the environmental variability (6).

First, the interrelations of weight per root, percentage sucrose, and percentage apparent purity will be considered. A study of table 8 reveals that the differences in weight per root at the three levels of nitrogen application are not significantly different for 1958. This is true even though there is an increase of total nitrogen in the thin juice and nitrate nitrogen in the petioles. Apparently each of the three applications of fertilizer provided sufficient nitrogen for maximum weight of root under the conditions of the experiment in 1958. There was a difference in weight per root as regards fertilizer applications in 1956 and a difference between the years, the weight per root being higher in 1958 than in 1956. These findings should be kept in mind when interpreting the simple correlation coefficients.

The correlation coefficients and percentages of the variances accounted for by regression (r^2 X 100) are listed in table 9. A study of the data in the columns headed "Sucrose" and headed "Purity" reveals that as weight per root increased percentage sucrose and percentage apparent purity decreased. The correlation coefficient for weight per root and percentage sucrose is -0.90. Hence 81 percent of the environmental variability of percentage sucrose is accounted for by regression or covariance. The correlation coefficient for weight per root and percentage apparent purity is -0.86 and 74 percent of the environmental variability and is accounted for by regression. One of the larger percentages of the environmental variability accounted for by regression is that between percentage sucrose and percentage apparent purity, 98 percent of the environmental variability being

accounted for by regression. Hence, under the conditions of this experiment, increased applications of nitrogen in the fertilizer resulted in no further increase in weight per root but resulted in a material reduction in both percentage sucrose and percentage apparent purity.

The correlation coefficients and the percentage of the variances accounted for by regression of weight per root, percentage sucrose, and percentage apparent purity on other chemical characters are listed in table 9, also. The regression of weight per root, percentage sucrose, and percentage apparent purity on total nitrogen in the thin juice accounts for 77, 94, and 98 percent, respectively, of the environmental variability of these three characters. The relations with glutamic acid and betaine are very similar as are those with total nitrogen. The correlation coefficient involving weight per root is positive, whereas those involving percentage sucrose and percentage apparent purity and total nitrogen are negative. Nitrate nitrogen in the petioles is positively associated with weight per root and negatively associated with percentage sucrose and percentage apparent purity. Regression accounted for 41, 56, and 71 percent of the environmental variability. Weight per root is negatively associated with phosphorus, whereas percentage sucrose and percentage apparent purity are positively associated with phosphorus. Regression accounted for 90, 96, and 88 percent of the environmental variability. A relatively minor portion of the environmental variability of weight per root, percentage sucrose, and percentage apparent purity is accounted for by the regression of these characters on potassium; the values being 15, 5, and 8 percent, respectively. The percentages of the environmental variability accounted for by regression of weight per root, percent sucrose and percent apparent purity on sodium are 96, 77, and 66, respectively. The relations are negative for percentage sucrose and percentage apparent purity. Total nitrogen and the nitrogenous compounds in the thin juice, and phosphorus and sodium in the petioles are most closely associated with weight per root, percentage sucrose, and percentage apparent purity.

Table 9. Correlation coefficients for ten characters and percentages of the variances accounted for by regression, differences between fertilizer treatments and between years, 1956 and 1958. 1/

Character	Sucrose		Thin juice								Petioles							
			Purity		Nitrogen		Glutamic acid		Betaine		Nitrate N		Phosphorus		Potassium		Sodium	
	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)	r	r²(100)
Weight	-0.90	81	-0.86	74	0.88	77	0.83	69	0.91	83	0.64	41	-0.95	90	-0.39	15	0.98	96
Sucrose			0.99	98	-0.97	94	-0.90	81	-0.997	99	-0.75	56	0.98	96	0.22	5	-0.88	77
Purity (thin juice)					-0.99	98	-0.94	88	-0.99	98	-0.84	71	0.94	88	0.29	8	-0.81	66
Nitrogen (thin juice)							0.97	94	0.99	98	0.88	77	-0.94	88	-0.40	16	0.82	67
Glutamic acid (thin juice)									0.92	85	0.94	88	-0.85	72	-0.58	34	0.74	55
Betaine (thin juice)											0.78	61	-0.97	94	-0.27	7	0.88	77
Nitrate nitrogen (petioles)													-0.65	42	-0.61	37	0.49	24
Phosphorus (petioles)															0.24	6	-0.95	90
Potassium (petioles)																	-0.26	7

1/ The value of r at the 5% level approximates 0.174.

The correlation coefficients for nitrogen, glutamic acid, betaine, nitrate nitrogen, phosphorus, potassium, and sodium, and the percentages of the variances accounted for by regression are listed in table 9. It should be kept in mind they are calculated from the data for A54-1 for 1956 and 1958. Total nitrogen in the thin juice is very closely associated with glutamic acid and betaine and is rather closely associated with nitrate nitrogen, phosphorus, and sodium. The percents of the environmental variability accounted for by regression are 94, 98, 77, 88, and 67, respectively. The association is positive for glutamic acid, betaine, nitrate nitrogen and sodium and negative for phosphorus and potassium. The only other close association is between phosphorus and sodium in the petioles, 90 percent of the variability being accounted for by regression. The association is negative. The relation between potassium and sodium is negative and only 7 percent of the variances is accounted for by regression. The negative relation is due to the differential behavior of these two characters in 1956 on the non-fertilized as compared with the fertilized plots. There was a decrease in potassium and an increase in sodium in going from the non-fertilized to the fertilized plots in 1956 (see table 8). For the 1958 data both decrease with increased applications of nitrogen in the fertilizer. When such interactions occur, it must be kept in mind that the correlation coefficients present average relations and to obtain all of the information, data such as listed in table 8 must be studied in detail.

Genetic variability

The average interrelations attributable to genetic variability are shown by the correlation coefficients and the percentages of the variances accounted for by regression (r^2 X 100) in tables 10 and 11. These constants measure the degree of association between characters whose variability is attributable, primarily, to differences between populations and hence are primarily genetic. The variability of the characters contains only a negligible amount due to environmental differences.

The data for both the fertilized and non-fertilized plots are given in table 10. The relation between weight per root and percentage sucrose is positive on both the non-fertilized and fertilized plots, 76 percent of the variability being accounted for in the former case and 29 percent in the latter. The association between weight per root and purity is not close on both fertilizer treatments, only 7 percent of the variability being accounted for by regression on the non-fertilized plots and practically none on the fertilized plots. On the fertilized plots regression accounted for 53 percent of the variability involving percentage sucrose and percentage apparent purity. This represents a decided increase in the proportion of the variance accounted for by regression calculated from the fertilized plots compared with the proportion accounted for by regression calculated from the non-fertilized plots. As was the case for the environmental variability, the relation is positive.

Table 10. Correlation coefficients for twelve characters and percentages of the variances accounted for by regression, differences between populations, 1956. 1/

Character and treatment			Thin juice														Petioles							
	Sucrose		Purity		Nitrogen		Glutamic acid		Betaine		Potassium		Sodium		Nitrate N		Phosphorus		Potassium		Sodium	
	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$
Weight																								
Non-fertilized	0.87	76	0.27	7	0.52	27	0.56	31	0.13	2	0.43	18	0.31	10	0.83	69	-0.29	8	-0.03	0	0.48	23
Fertilized	0.54	29	-0.06	0	0.66	44	0.72	52	-0.27	7	0.47	22	0.45	20	0.72	52	-0.26	7	-0.46	21	0.41	17
Sucrose																								
Non-fertilized			0.12	1	0.58	34	0.66	44	0.04	0	0.29	8	-0.08	1	0.54	29	-0.70	49	-0.48	23	0.06	0
Fertilized			0.73	53	-0.19	4	0.12	1	-0.90	81	-0.42	18	-0.30	9	0.26	7	-0.17	3	-0.18	3	-0.13	2
Purity (thin juice)																								
Non-fertilized					-0.67	45	-0.57	32	-0.78	61	-0.68	46	-0.32	10	0.10	1	0.04	0	0.30	9	-0.06	0
Fertilized					-0.75	56	-0.40	16	-0.93	86	-0.90	81	-0.35	12	-0.05	0	0.39	15	0.47	22	-0.08	1
Nitrogen (thin juice)																								
Non-fertilized							0.93	86	0.81	66	0.89	79	0.46	21	0.56	31	-0.33	11	-0.41	17	0.38	14
Fertilized							0.85	72	0.49	24	0.95	90	0.55	30	0.60	36	-0.42	18	-0.60	36	0.40	16
Glutamic acid (thin juice)																								
Non-fertilized									0.64	41	0.77	59	0.29	8	0.52	27	-0.50	25	-0.45	20	0.18	3
Fertilized									0.17	3	0.73	53	0.45	20	0.61	37	-0.32	10	-0.52	27	0.45	20
Betaine (thin juice)																								
Non-fertilized											0.90	81	0.72	52	0.49	24	0.16	3	-0.11	1	0.57	32
Fertilized											0.71	50	0.25	6	-0.22	5	-0.22	5	-0.26	7	-0.01	0
Potassium (thin juice)																								
Non-fertilized													0.80	64	0.63	40	0.13	[illegible]	0.03	0	0.68	46
Fertilized													0.50	25	0.36	13	-0.44	19	-0.60	36	0.28	8
Sodium																								
Non-fertilized															0.68	46	0.66	44	0.57	32	0.94	88
Fertilized															0.64	41	0.50	25	0.28	8	0.92	85
Nitrate nitrogen (petioles)																								
Non-fertilized																	0.09	1	0.17	3	0.77	59
Fertilized																	0.14	2	0.00	0	0.75	56
Phosphorus (petioles)																								
Non-fertilized																			0.89	79	0.62	38
Fertilized																			0.96	92	0.64	41
Potassium (petioles)																								
Non-fertilized																					0.57	32
Fertilized																					0.45	20

1/ The value of r at the 5% level approximates 0.159.

The correlation coefficients and the percentages of the variances accounted for by regression of weight per root, percentage sucrose, and percentage apparent purity on other chemical characters are listed in table 10 also. They were calculated from differences between populations and are from the 1956 data.

A study of table 10 reveals that the strongest association of characters for weight per root is with nitrate nitrogen in the petioles. Here for the non-fertilized and the fertilized plots 69 and 52 percent of the variability is accounted for by regression. The next strongest associations as regards weight per root are with glutamic acid and total nitrogen in the thin juice. The percents of the variability accounted for by regression for the non-fertilized and fertilized plots are 31 and 52, and 27 and 44 percent, respectively.

For percentage sucrose the closest association on the non-fertilized plots is with phosphorus. It is negative and only 49 percent of the variability is accounted for by regression. The next strongest associations on the non-fertilized plots are with glutamic acid and total nitrogen in the thin juice. For the fertilized plots the strongest association is with betaine in the thin juice and is negative. Here 81 percent of the variability is accounted for by regression.

For percentage apparent purity the strongest associations are with betaine, potassium, and total nitrogen in the thin juice, regression accounting for 86, 81, and 56 percent of the variability on the fertilized plots and 61, 46, and 45 percent on the non-fertilized plots, respectively. With the possible exception of glutamic acid, the percentages of the variances accounted for by regression of purity and the other characters both on the non-fertilized and fertilized plots are comparatively small. The closest association between percentage apparent purity and any character taken from petiole samples is with potassium. The association is positive. The relation between potassium and percentage apparent purity in the thin juice was negative. These data definitely show that as regards the genetic variability the association between purity and potassium in the thin juice is the reverse of that in the petioles. The same conclusion can be drawn for weight of root and potassium in the thin juice and in the petioles, with the exception that the relation is reversed; that is, the relation is positive in the thin juice and negative in the petioles or non-significant, the correlation coefficient being only -0.03 for the non-fertilized plots. It is clear that the relations found existing between potassium and the three characters weight per root, percentage sucrose, and percentage apparent purity in the petioles cannot be taken as a measure of the relations between potassium in the thin juice and these same three characters.

The genetic correlation coefficients and percentages of the variances accounted for by regression for total nitrogen, glutamic acid, betaine, potassium (thin juice), sodium (thin juice), nitrate nitrogen, phosphorus, potassium (petioles) and sodium (petioles) are listed in table 10 also. The data are for 1956.

Total nitrogen, glutamic acid, and betaine in the thin juice are positively associated with potassium in the thin juice on both the non-fertilized and fertilized plots and are negatively associated with potassium in the petioles. In the thin juice 79 and 90, 59 and 53, and 81 and 50 percents of the variances are accounted for by regression on the non-fertilized and fertilized plots, respectively, whereas in the petioles the values are 17 and 36, 20 and 27, and 1 and 7 percents, respectively. These relations can be accounted for if both total nitrogen and potassium are being accumulated in the roots at the expense of the tops. If such is the case one would expect a negative correlation between potassium in the thin juice and potassium in the petioles. There is no significant relation between potassium in the thin juice and potassium in the petioles on the non-fertilized plots, but there is a relation between them on the fertilized plots and it is negative as expected.

Total nitrogen, glutamic acid, and betaine in the thin juice and sodium in both the thin juice and petioles are positively correlated, with the exception of betaine and sodium in the petioles on the fertilized plots. The percents of the variances accounted for by regression are 21 and 30, 8 and 20, and 52 and 6 in the thin juice and 14 and 16, 3 and 20, and 32 and 0 in the petioles.

Total nitrogen in the thin juice and nitrate nitrogen in the petioles are positively correlated and the percents of the variances accounted for by regression are 31 and 36, respectively, for the non-fertilized and the fertilized plots. Phosphorus in the petioles is negatively associated with total nitrogen. This is true for both fertilizer treatments and the percentages of the variances accounted for by regression are 11 and 18 percent, respectively, for the non-fertilized and fertilized treatments.

All of the percentages of the variances accounted for by regression of total nitrogen on each of the other characters listed in table 10 are significantly different from zero. This follows from the fact that the correlation coefficients are significantly different from zero.

On both the non-fertilized and the fertilized plots potassium in the thin juice is significantly associated with all the other characters with the exceptions of phosphorus and potassium in the petioles on the non-fertilized plots. Also the associations are all positive, with the exception of phosphorus and potassium in the petioles on the fertilized plots. Here they are negative. Sodium in the thin juice is positively associated with all other characters, excepting sucrose and purity listed in table 10, the association being strongest for sodium in the thin juice and sodium in the petioles. This is in striking contrast with the behavior of potassium in the thin juice, which shows a negative association with potassium in the petioles.

Nitrate nitrogen in table 10 for the statistically significant values shows positive relations with all characters excepting purity and betaine on the fertilized plots, the association with purity being negligible. Also the association with phosphorus and potassium in the petioles are negligible. Nitrate nitrogen in the petioles is rather closely associated with sodium in the petioles, 59 and 56 percent of the variances being accounted for by regression on the non-fertilized and fertilized plots, respectively.

Phosphorus and potassium in the petioles will be considered together, as their relations with all the other characters in table 10 are very similar. This is also true of the relations shown in table 9. Both of these chemical characters are negatively associated with nitrogen in the thin juice, are negatively associated with potassium in the thin juice on the fertilized plots, and show no significant relation with this character on the non-fertilized plots (see table 10). Both are positively associated with sodium in the thin juice and in the petioles. Neither phosphorus nor potassium in the petioles shows significant association with nitrate nitrogen in the petioles. As might be expected, since these two characters show such similar association patterns with other characters, the closest relations are with each other, 79 and 92 percent of the variances being accounted for by regression.

Both sodium in the thin juice and sodium in the petioles show significant positive associations with all other characters listed in table 10, excepting sucrose and purity and excepting betaine on the fertilized plots. Their behavior patterns are very similar and, as would be expected, the closest associations are between sodium in the thin juice and sodium in the petioles, 88 and 85 percent of the variances being accounted for by regression. The next strongest association is with nitrate nitrogen in the petioles.

The genetic correlation coefficients and the percentages of the variances accounted for by regression for the eleven characters studied in 1958 are listed in table 11.

Table 11. Correlation coefficients for eleven characters and percentages of the variances accounted for by regression, differences between populations, average of three treatments, 1958. 1/

Character	Sucrose		Thin juice										Petioles							
			Purity		Nitrogen		Glutamic acid		Betaine		Chlorides		Nitrate N		Phosphorus		Potassium		Sodium	
	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$	r	$r^2(100)$
Weight	0.12	1	0.31	10	-0.37	14	-0.15	2	-0.73	53	0.36	13	0.83	69	-0.38	14	0.71	50	0.59	35
Sucrose			0.68	46	-0.59	35	-0.57	32	0.00	0	-0.07	0	-0.04	0	0.66	44	0.12	1	-0.63	40
Purity					-0.96	92	-0.95	90	-0.66	44	0.09	1	0.46	21	0.59	35	0.56	31	-0.37	14
Nitrogen (thin juice)							0.97	94	0.74	55	-0.37	14	-0.61	37	-0.62	38	-0.75	56	0.17	3
Glutamic acid (thin juice)									0.64	41	-0.27	7	-0.46	21	-0.74	55	-0.62	38	0.32	10
Betaine (thin juice)											-0.42	18	-0.94	88	0.01	0	-0.89	79	-0.42	18
Chlorides (thin juice)													0.64	41	0.22	5	0.76	58	0.61	37
Nitrate N (petioles)															-0.11	1	0.96	92	0.65	42
Phosphorus (petioles)																	0.16	3	-0.61	37
Potassium (petioles)																			0.52	27

1/ The value of r at the 5% level approximates 0.115.

Weight of root and percentage sucrose show very little association, only 1 percent of the variances being accounted for by regression. Also, weight of root and percentage apparent purity are associated positively; but only 10 percent of the variances are accounted for by regression. The association between percentage sucrose and percentage apparent purity is positive, and 46 percent of the genetic variances are accounted for by regression. This latter association is sufficiently close to aid materially in breeding sugar beets high in both sucrose and purity when it is found to occur.

The correlation coefficients and percentages of the variances accounted for by regression for weight per root, percentage sucrose, and percentage apparent purity with total nitrogen in the thin juice; and nitrate nitrogen, phosphorus, potassium, and sodium in the petioles are listed in table 11, also. All of the correlation coefficients and, hence, percentages of the variances accounted for by regression involving weight per root, with the exception of the association with sucrose are significant at the 5% level. The associations with total nitrogen and the other nitrogenous compounds in the thin juice and phosphorus in the petioles are negative; whereas, those with chlorides in the thin juice and nitrate nitrogen, potassium, and sodium in the petioles are positive. For nitrate nitrogen and potassium the associations are fairly close, regression accounting for 69 and 50 percent of the genetic variances, respectively. Sucrose and purity are negatively associated with total nitrogen and the nitrogenous compounds in the thin juice and sodium in the petioles. The associations with chlorides are not statistically significant. The other associations with the exception of sucrose and nitrate nitrogen in the petioles are positive. However, the correlation involving percentage sucrose and nitrate nitrogen is not significantly different from zero. All of the correlation coefficients with percentage apparent purity excepting the one with chlorides are significantly different from zero at the 5-percent level. The associations between purity and total nitrogen and glutamic acid are very close, 92 and 90 percent of the genetic variances being accounted for by regression. An examination of table 4 shows that the high correlation coefficient is almost entirely due to the low purity and high total nitrogen of inbred 55-5307 as compared with the other populations. In none of the other relations of sucrose and purity with the chemical characters is as much as 50 percent of the genetic variance accounted for by regression.

The correlation coefficients and percentage of the variances accounted for by regression for the chemical characters other than sucrose, for 1958, are listed in table 11 also. Again these values are calculated from differences between populations and hence are genetic. Nitrogen in the thin juice is negatively associated with chlorides in the thin juice and with nitrate nitrogen, phosphorus, and potassium in the petioles. The percentages of the variances accounted for by regression are 14, 37, 38, and 56, respectively. With the possible exceptions of nitrate nitrogen, potassium, and

sodium, all in the petioles, the associations involving chlorides are not close. However, all are statistically significant excepting those with sucrose, purity, and phosphorus. The percentage of the variance accounted for by the regression of nitrate nitrogen on phosphorus is negligible, on potassium is 92 percent, and on sodium is 42 percent. The association between the latter two and nitrate nitrogen is positive. The association between phosphorus and potassium is negligible and between phosphorus and sodium is negative, 37 percent of the genetic variability being accounted for by regression. The association between potassium and sodium is positive, 27 percent of the variability being accounted for by regression.

Combining Ability and Dates of Harvest Tests

The population genetic studies conducted in 1956 provided data pertaining to whether populations differ in their ability to produce maximum yields together with maximum percentages of sucrose. Maximum weights; percentages sucrose and corresponding percentages apparent purity; concentrations of total nitrogen in the petioles for populations A54-1, 50-406BB, and the F_1 (50-406 X 52-307) are listed in table 12. These may be considered as combining ability tests of the top-cross and F_1 hybrid compared with the commercial variety A54-1. These data are from Powers et al (9, table 8).

Table 12. Maximums for weight per root, percentage sucrose and corresponding percentage apparent purity, concentrations of nitrogen in the thin juice, and concentrations of nitrate nitrogen in the petioles at time of harvest for populations A54-1, 50-406BB, and F_1 (50-406 X 52-307), 1956.

Population and treatment	Weight per root	Sucrose	Apparent purity	Nitrogen	Nitrate nitrogen
	Lbs.	%	%	Mg.	Ppm
A54-1					
Non-fertilized	1.66	18.4	97.0	12.6	452
Fertilized	2.90	17.1	94.2	38.6	1724
50-406BB					
Non-fertilized	1.43	18.0	97.5	10.8	406
Fertilized	2.24	18.1	95.3	25.7	1050
F_1(50-406 X 52-307)					
Non-fertilized	1.39	18.3	97.8	8.8	374
Fertilized	2.49	18.5	95.5	17.8	390
LSD at 5% level	0.12	0.3	0.4	3.2	817

Weight per root for A54-1 in the replication group having the greatest weight is 2.90 pounds and is accompanied by 17.1 percent sucrose and occurs on the fertilized plots. The maximum percentage sucrose for any replication group is 18.4 percent and is accompanied by a root weight of 1.66 pounds and occurs on the non-fertilized plots. For 50-406BB the maximum weight per root for any replication group is 2.24 pounds, and is accompanied by 18.1 percent sucrose which is also the maximum percent sucrose for this population. On the non-fertilized plots the maximum percent sucrose for any replication group is 18.0 and it is accompanied by a root weight of 1.43 pounds. For the F_1 hybrid the maximum weight per root for any replication group is 2.49 pounds which is accompanied by 18.5 percent sucrose. This is also the maximum for percentage sucrose. The maximum for percentage sucrose of any replication group on the non-fertilized plots is 18.3 and is accompanied by a root weight of 1.39 pounds. From these data it is evident that as regards weight per root and percentage sucrose A54-1 is responding differently to the high fertility level than are 50-406BB and the F_1 hybrid. That is, both of these hybrids have the maximum weight per root and maximum percentage sucrose occurring in the same replication group and occurring on the fertilized plots. This is not true of A54-1. The F_1 produces as high percentage sucrose on the fertilized plots as does A54-1 on the non-fertilized plots and the weight per root of the F_1 on the fertilized plot is 50 percent greater than that of the F_1 on the non-fertilized plot. However, on the fertilized plots A54-1 outyields the F_1 hybrid in weight per root by 16 percent.

On the other hand, maximum yields and maximum sucroses are not accompanied by the highest purities listed in table 12. In every case the higher purities occur on the non-fertilized plots and the highest purity is for the F_1 hybrid. A study of the data in table 12 reveals that the purities are closely associated with total nitrogen in the thin juice, and concentrations of nitrate nitrogen in the petioles, but with the latter to a smaller degree.

It is clear that the breeder can do much to improve both percentage sucrose and percentage apparent purity. The improvement in percentage sucrose will result from the fact that for certain hybrids, higher concentrations of nitrogen in the thin juice, up to certain limits, is not accompanied by a reduction in sucrose content, as compared with other populations, and to the fact that certain hybrids have a lower concentration of total nitrogen in the thin juice, as compared with other populations, under the same fertilizer practices (see table 2). The increase in percentage apparent purity is associated with the latter phenomenon; that is, some populations have less total nitrogen in the thin juice than other populations.

These findings raise the question as to whether genotypes (populations) might not differ as to the length of the growing season required to obtain acceptable percentages of sucrose and acceptable weights per root. In 1961 an experiment was conducted to determine whether such might be the case. Part of the data are tabulated in table 13.

Table 13. Means of weight per plot, percentage sucrose, and sugar per plot for three dates of harvest, 1961.

Population	Weight per plot			Percentage sucrose			Sugar per plot		
	Sept. 14	Oct. 3	Oct. 16	Sept. 14	Oct. 3	Oct. 16	Sept. 14	Oct. 3	Oct. 16
	Kg.	Kg.	Kg.	%	%	%	Kg.	Kg.	Kg.
52-430 X 54-565 F_1	4.45	5.02	4.94	15.5	16.0	17.3	0.6881	0.8018	0.8567
52-430 X 54-346 F_1	5.50	5.54	5.36	14.6	16.3	17.7	0.7982	0.9011	0.9528
52-430 X 52-408 F_1	7.11	7.48	7.49	14.4	15.5	16.7	1.0218	1.1618	1.2446
A56-3	7.54	8.02	7.97	12.5	14.2	15.2	0.9313	1.1290	1.2092
LSD at 5% level	0.59	0.77	0.81	0.6	0.6	0.5	0.0955	0.1195	0.1355

The data show that undoubtedly there are four levels of yield represented by the four populations. The F_1 hybrid 52-430 X 52-408 averages 6.2 percent lower weight per plot than does the commercial variety, 56-3. The yields of all populations increased from September 14 to October 3, but none of the population yields increased after October 3.

The data for percentage sucrose reveals that, when harvested September 14, all of the F_1 hybrids have from 1.9 to 3.0 percent more sucrose than does A56-3, the commercial variety with which they are compared. Moreover, all of the hybrids had higher percentage sucrose harvested on September 14, than did the commercial variety harvested on October 3 and the sucrose content of 52-430 X 54-565 was significantly higher than that of A54-1. In fact, this hybrid had as high a percentage sucrose content harvested on September 14 as did the commercial variety harvested on October 16. Likewise, all of the hybrids had higher percentages sucrose harvested on October 3 than did the commercial variety harvested on October 16. In the case of the first two hybrids listed, they averaged about 1 percent higher sucrose harvested on October 3 than did the commercial variety harvested on October 16. Finally, the F_1 hybrids harvested on October 16 had from 1.5 to 2.5 percent higher sucrose than did the commercial variety. It is clear that hybrid populations can be obtained that will have as high a percentage sucrose as this commercial variety when harvested from two weeks to one month earlier.

A study of the data for yield of sugar per plot reveals that hybrid 52-430 X 52-408 produces more sugar per plot for all 3 dates of harvest than does the commercial variety, and the difference for September 14 approaches statistical significance. Moreover, this hybrid harvested on September 14 produced within 9 percent as much sugar per plot as did the commercial variety harvested on October 3, and within 15 percent as much sugar per plot as did the commercial variety harvested on October 16, approximately one month later. Hybrid 52-430 X 52-408 harvested on October 3 produced within 4 percent as much sugar as did the commercial variety harvested on October 16.

The fact that the hybrids studied in these researches do not have as great a weight per root as the commercial variety raises the problem whether the physiological relations between weight per root, percentage sucrose, and percentage apparent purity are such that hybrid populations cannot be obtained that will exceed the commercial variety in all three characters. Some information pertaining to a solution of this problem is provided by the data listed in table 14. The F_1 hybrid exceeds the commercial variety A54-1 in weight per root, percentage sucrose and percentage apparent purity. The differences are statistically significant at the 5 percent level. The question still remains as to what extent the plant breeder can increase these three characters simultaneously. It is apparent from these data that they can be increased simultaneously under the conditions which this experiment was conducted in 1960. An amount of nitrogen was applied in the spring of the year which it was hoped would result in optimum amounts of N being available for the production of near maximum yields of roots; that is, 100 pounds of N and 250 pounds of P_2O_5 were applied per acre. The 250 pounds of P_2O_5 were applied in the previous autumn and plowed under.

Table 14. Means and their standard errors for weight per root, percentage sucrose, and percentage apparent purity, 1960. 1/

Population	Weight	Sucrose	Purity
	Kg.	%	%
A54-1	1.12±0.031	16.9±0.178	91.9±0.258
F_1 (52-430 X 52-307)	1.21±0.025	17.8±0.140	92.9±0.196
Difference	0.09±0.040	0.9±0.226	1.0±0.324

1/ The estimates of the standard errors include differences between replication means and therefore are over estimates.

Discussion and Conclusions

The discussion and conclusions will be divided into environmental variability, phenotypic-dominance phenomena, and combining ability and dates of harvest tests.

The characters studied of greatest agronomic importance are weight per root, percentage sucrose, and percentage apparent purity. The chemical determinations made on thin juice samples are total nitrogen, glutamic acid, betaine, potassium, sodium, and chloride. Total nitrogen, glutamic acid, betaine, and chloride are expressed as milligrams per 100 milliliters of thin juice equated to a refractometer reading of 10. In the thin juice, potassium and sodium are expressed as parts per 100,000. The determinations made from petiole samples are nitrate nitrogen, phosphorus, potassium, and sodium. They are expressed as parts per million.

Environmental Variability

The associations attributable to environmental variability will be considered first. It will be remembered that two years and five fertilizer treatments contributed much of the environmental variability. Weight per root is negatively associated with percentage sucrose and percentage apparent purity, 81 and 74 percent of the variability, respectively, of sucrose and purity being accounted for by that of weight per root; that is, on an average, the roots having the smaller weights tended to have the higher percentages sucrose and the higher percentages apparent purity.

As would be expected, total nitrogen in the thin juice is positively associated with weight per root, 77 percent of the variability of one being accounted for by that of the other. However, after a certain concentration of nitrogen in the thin juice had been reached, no further increase in weight per root resulted. An increase from 18.8 milligrams of nitrogen per 100 milliliters of thin juice to 46.8 milligrams is associated with an increase in weight per root from 1.93 pounds to 2.60 pounds. An increase from 46.8 milligrams of nitrogen in the thin juice to 62.9 is accompanied by an increase in weight per root of only 0.39 pounds and a decrease in percent sucrose and percent apparent purity of 2.2 and 4.0, respectively. Above 62.9 milligrams of nitrogen per 100 milliliters of thin juice, there is no further increase in weight per root. This is true even though a 300 pound application of N in the fertilizer increased the concentration of total nitrogen to 103.5 milligrams per 100 milliliters of thin juice. Then, in this experiment, the maximum weight per root was reached with a concentration of total nitrogen in the thin juice lying somewhere between 46.8 and 62.9 milligrams per 100 milliliters of thin juice equated to a refractometer reading of 10.

Weight per root is positively associated with nitrate nitrogen and sodium in the petioles and negatively associated with phosphorus and potassium in the petioles. The association is high for phosphorus and sodium,

89 and 96 percent, respectively, of the variability of weight per root being accounted for by the variability of these two characters.

Percentage sucrose and percentage apparent purity will be considered together. These two characters are very closely associated as regards the environmental variability, 98 percent of the variability of one being accounted for by that of the other. The association is positive; that is, an increase in percentage sucrose is accompanied, on an average, by an increase in percentage apparent purity. The characters most closely associated with sucrose and purity are total nitrogen and betaine in the thin juice and phosphorus in the petioles, 94 and 98, 99 and 98, and 96 and 98 percents, respectively, of the environmental variabilities of percentage sucrose and percentage apparent purity being accounted for by regression. The associations are negative with total nitrogen and betaine and positive with phosphorus. In going from 18.8 milligrams of total nitrogen in the thin juice to 103.5, there is a decrease from 17.9 percent sucrose to 13.0 percent and a corresponding decrease in percentage purity from 96.1 percent to 82.7 percent. The corresponding changes in betaine are from 89.8 mg to 190.4 mg and for phosphorus are from 1798 ppm to 1238 ppm.

Although the increases in concentrations of nitrogen and betaine in the thin juice were accompanied by decreases in percentage sucrose and percentage apparent purity, the reductions were not marked until a concentration of 46.8 and 116.6 milligrams per 100 milliliters of thin juice, or greater, had been reached. The decreases in these two characters were not marked until a concentration of 1598 ppm, or lower, of phosphorus in the petioles had been reached.

In relation to sucrose and apparent purity,potassium in the petioles follows a behavior pattern very similar to that of phosphorus. However, the associations are not so strong.

Sodium in the petioles is highly associated with sucrose and purity, and the relation is negative. The relation is almost entirely due to differences between years and the differential behavior of sodium for the two years. In going from the non-fertilized plots in 1956 to the fertilized plots, sodium increased from 10940 parts per million of sodium in the petioles to 15265 parts per million; whereas, in 1958, in going from a 50 pound application of nitrogen in the fertilizer to a 300 pound application, sodium decreased in the petioles from 19430 parts per million to 18115 parts per million. Since, with increased applications of nitrogen in the fertilizer, sucrose and apparent purity percentages decrease both within and between years, the associations with sodium and these two characters are negative. These results emphasize the importance of studying the data in detail when interactions are occurring, such as noted for sodium, years, and treatments.

The interrelations of the chemical characters: total nitrogen, glutamic acid, and betaine in the thin juice, and nitrate nitrogen, phosphorus, potassium, and sodium all in the petioles, follow two behavior patterns. Total nitrogen, glutamic acid, and betaine in the thin juice, and nitrate nitrogen and sodium in the petioles are positively associated with each other and negatively associated with phosphorus and potassium in the petioles. Hence, as might be expected, phosphorus and potassium are positively associated with each other and negatively associated with total nitrogen, glutamic acid, betaine, nitrate nitrogen, and sodium. As has been shown, these same two behavior patterns exist as regards the relations of these elements with weight per root, percentage sucrose, and percentage apparent purity. Weight per root was positively associated with total nitrogen, glutamic acid, betaine, nitrate nitrogen, and sodium and negatively associated with phosphorus and potassium. The reverse was true of the relation between these same chemical constituents and sucrose and purity.

Before leaving a consideration of the environmental variability, it might be well to draw some conclusions.

It is interesting to note that total nitrogen in the thin juice seems to team up with phosphorus and potassium in forming a consistent behavior pattern and nitrate nitrogen and sodium seem to team up to form another consistent behavior pattern. The relations of phosphorus and potassium in the petioles, with each other and particularly with other characters, are those expected if these two elements are associated in their absorption from the soil. Phosphorus is an anion and potassium is a cation. Likewise, the relations between nitrate nitrogen and sodium in the petioles and their relations with other characters are those expected if these two elements are associated in their absorption from the soil. Nitrate nitrogen is an anion and sodium is a cation.

Genetic Variability

Turning to a consideration of the genetic variability for 1956 which represents differences between populations on the fertilized plots, weight of root and percentage sucrose are positively associated, but only 29 percent of the variability of one is accounted for by that of the other. This positive relation is due to the fact that the two hybrid populations have both a greater weight per root and a higher percentage sucrose than the two inbreds. This shows that on the fertilized plots both higher weight per root and higher percentage sucrose can be obtained if certain populations are grown. However, A54-1 and A54-1BB have greater weights per root and lower percentages of sucrose than the two hybrid populations. Hence, the question still remains as to what extent both greater weight of root and higher percentage sucrose can be combined. The association between weight per root and percentage apparent purity was negligible. This indicates that by appropriate breeding procedures it should be possible to increase both weight of root and percentage apparent purity.

Percentage sucrose and percentage apparent purity, as is true for the environmental variability, are again rather highly associated positively. Fifty-three percent of the genetic variability of one was associated with that of the other. Since as percentage sucrose increased there was, on the average, an increase in apparent purity, the task of increasing both of these characters by breeding would be easier than if no relation existed.

In studying the genetic variability it was found that total nitrogen in the thin juice is negatively associated with both percentage sucrose and apparent purity. There is a decided interaction between genotype and fertilizer treatment for percentage sucrose. This is shown by comparing A54-1 and the F_1 on both fertilizer treatments. For A54-1 there was a reduction of 1.1 percent in sucrose on the fertilized plots compared with the non-fertilized plots, whereas the percentage sucrose was the same for the F_1 hybrid on both fertilizer treatments. A comparison of these same populations as regards total nitrogen in the thin juice and percentage sucrose is informative. For A54-1 the percents sucrose on the non-fertilized plots and the fertilized plots were 17.9 and 16.8 accompanied by concentrations of nitrogen in the thin juice of 18.8 and 46.8. The same relations for the F_1 are sucrose 17.6 and 17.6 and nitrogen 9.8 and 21.3. It should be noted that the F_1 on the fertilized plots does not have a materially greater concentration of total nitrogen in the thin juice, than does A54-1 on the non-fertilized plots, the comparison being 21.3 to 18.8. Neither are the percents sucrose materially different, 17.6 compared with 17.9. This would indicate that these two genotypes under the environmental conditions of this experiment react similarly to total nitrogen in the thin juice. However, A54-1 has considerably more total nitrogen in the thin juice than does the F_1 and 52-307 on the fertilized plots. Hence, populations differ as to total nitrogen in the thin juice under identical fertilizer treatments. These same conclusions hold for glutamic acid and betaine but they are not so marked for betaine.

A comparison of 50-406BB and its female parent 50-406 shows that populations do not always react the same to total nitrogen in the thin juice as regards percentage sucrose. On the non-fertilized and fertilized plots the percents sucrose for 50-406BB are 17.6 and 17.3, respectively, and the corresponding values for 50-406 are 17.4 and 16.1. On the non-fertilized and fertilized plots the concentrations of total nitrogen for 50-406BB are 12.6 and 33.6, respectively, and the corresponding values for 50-406 are 14.6 and 31.2. This definitely represents a genotype-environment interaction, as an increase in milligrams of total nitrogen per 100 milliliters of thin juice to 33.6 for 50-406BB was accompanied by only a decrease in sucrose of 0.3 percent; whereas, for 50-406 a corresponding increase to 31.2 was accompanied by a decrease in sucrose of 1.3 percent. Obviously a higher concentration of total nitrogen in the thin juice is accompanied by a considerably smaller decrease in percentage sucrose for 50-406BB than is the case for 50-406. Stating it another way, at about the same concentration of total nitrogen in the thin juice, 33.6 and 31.2 milligrams per 100 milliliters of thin juice, 50-406BB has 17.3 percent sucrose as compared with 16.1 percent for 50-406. The corresponding values involving percentage apparent purity rather than percentage sucrose are 94.4 and 92.6. Hence, not only do some populations

have smaller concentrations of total nitrogen in the thin juice under identical fertilizer treatments but some populations have a higher percentage sucrose and higher percentage apparent purity than others at the same level of total nitrogen concentration in the thin juice. This conclusion holds for glutamic acid but not for betaine on the fertilized plots. However, they do hold for betaine and apparent purity on the non-fertilized plots.

These comparisons do not represent exceptional cases, as is shown by similar comparisons involving the populations grown in 1958 (see table 4). The F_1 hybrid has 13.5 percent sucrose, 87.5 percent purity, 79.1 mg of total nitrogen, 93.6 mg glutamic acid, and 162.4 mg of betaine; whereas, the corresponding values for A56-5BB$_1$ are 12.8, 86.6, 72.8, 89.3, and 140.8, respectively.

Another interesting association is that involving total nitrogen in the thin juice and nitrate nitrogen in the petioles on the fertilized plots. The populations that will be considered are A54-1, 50-406, F_1, and 52-307. A54-1 is highest in total nitrogen in the thin juice (46.8) and highest in nitrate nitrogen in the petioles (4233), 50-406 is next highest in total nitrogen in the thin juice (31.2) and lowest in nitrate nitrogen in the petioles (2297), the F_1 is second lowest in total nitrogen in the thin juice (21.3) and intermediate in nitrate nitrogen in the petioles (3060) and finally, 52-307 is lowest in total nitrogen in the thin juice (18.6) and second highest in nitrate nitrogen in the petioles (3644). That these data do not represent an exceptional case is shown by comparing populations A56-5BB, 52-430, and 55-5307 grown in 1958. The data are taken from table 4 as to the concentrations of total nitrogen in the thin juice and as to the concentrations of nitrate nitrogen in the petioles. A56-5BB has 71.2 milligrams of total nitrogen per 100 milliliters of thin juice, whereas, the corresponding concentration of nitrate nitrogen in the petioles is 6240; 52-430 has 73.8 milligrams of total nitrogen per 100 milliliters of thin juice, whereas, the corresponding concentration of nitrate nitrogen in the petioles is 3080; and finally, 55-5307 has 116.4 milligrams of total nitrogen per 100 milliliters of thin juice, whereas, the corresponding concentration of nitrate nitrogen in the petioles is 2865. Of considerable importance is the fact that the percentages of sucrose and percentages of apparent purity are very closely associated with total nitrogen in the thin juice and not necessarily with nitrate nitrogen in the petioles. This conclusion holds for both the environmental variability and the genetic variability.

These data show that, as regards the genetic variability, high nitrate nitrogen in the petioles is not necessarily associated with high total nitrogen in the thin juice. Nor is high nitrate nitrogen in the petioles necessarily associated with low total nitrogen in the thin juice. Also, the same was found to hold for the environmental variability; but the associations were closer between degrees of concentration of total nitrogen in the thin juice and concentrations of nitrate nitrogen in the petioles; that is, the exceptions to an increase in one being accompanied by an increase in the other

were fewer for the environmental variability than for the genetic variability. It is clear that relative concentrations of nitrate nitrogen in the petioles cannot always be taken as indicative of relative concentrations of total nitrogen in the thin juice. Further, it was found that relative concentrations of potassium in the petioles cannot always be taken as an indication of relative concentrations of potassium in the thin juice. For example, 52-307 had 24690 ppm of potassium in the petioles and only 99.4 parts per 100,000 of potassium in the thin juice; whereas, A54-1 had only 17695 ppm of potassium in the petioles and 133.1 parts per 100,000 in the thin juice. This genetically controlled decrease of 133.1 to 99.4 parts per 100,000 of potassium in the thin juice was accompanied by an increase of 1.7 percent in purity.

Before leaving the associations noted between characters due to environmental variability and those noted due to genetic variability, patterns of behavior common to both should be considered. It was found that nitrate nitrogen and sodium in the petioles followed one behavior pattern as regards their associations with other characters and phosphorus and potassium in the petioles another behavior pattern. In brief, nitrate nitrogen and sodium in the petioles are positively associated with each other and negatively associated with phosphorus and potassium in the petioles. Likewise, phosphorus and potassium in the petioles are positively associated with each other and negatively associated with nitrate nitrogen and sodium. These associations are interesting in connection with research findings of Arnon (1) and others. Arnon states that the absorption of phosphate would be expected to be depressed by the presence in the nutrient medium of high concentrations of rapidly absorbable anions and to be increased by an increase in the concentration of rapidly absorbable cations. He found that the absorption of the phosphate ion by roots is hindered by competition with the rapidly absorbable nitrate ion. He states that there are many observations on the reduction of phosphate absorption in soils by heavy applications of nitrate nitrogen. Since nitrate nitrogen is an anion and sodium is a cation, it seems logical, if one is influencing the absorption of the other, that their concentrations in the petioles are positively associated. Also, since phosphorus is an anion and potassium is a cation it seems logical that the concentration of these two elements in the petioles might be positively associated. The fact that the absorption of phosphorus is hindered by the nitrate anion might explain why the association between concentrations of phosphorus and concentrations of nitrate nitrogen in the petioles is negative. It is interesting to note that nitrate nitrogen seems to be "teamed up" with sodium and phosphorus with potassium.

Finally, the associations noted for total nitrogen in the thin juice of the sugar beet root and potassium in the thin juice and phosphorus and potassium in the petioles are those expected if phosphorus and potassium are involved in the metabolic and translocation processes that result in increased amounts of total nitrogen in the thin juice. This postulation is supported by the negative relation between potassium in the thin juice and potassium in the petioles on the fertilized plots. A comprehensive review of the literature and conclusions pertaining to translocation in plants is

given by Crafts (2). Also, Arnon (1) presents an excellent discussion of the translocation of phosphorus in plants.

From a study of the means in tables 2 to 5 inclusive, it is apparent that all of the 13 characters listed possess both genetic and environmental variability. This is important as the environment can be controlled to some extent by fertilizer and cultural practices and the genotype can be controlled to a considerable extent by breeding. It is also clear that there are interactions between the genotypes and the environment; that is, all genotypes are not reacting the same to all environments. Hence, to obtain high yields of sugar per acre and to obtain beets high in processing quality the genotype and environment, and the genotype-environment interactions must be taken into account. A study of the means makes it clear that genotype-environment interactions are of very considerable importance in determining the advances that can be made by the plant breeder.

The fact that, as regards both the environmental and genetic variabilities, percentage apparent purity is negatively associated with all other characters in the thin juice with the possible exception of chlorides, and that predominantly the same is true of percentage sucrose with the exception of purity, warrants further discussion of the genetic implications of these findings. First, it is evident that since the characters differ they must differ also in some of the genes controlling their differentiation and production. Hence, the least number of genes differentiating and controlling differences in percentages of sucrose and differences in percentages of purity would be the number of such characters studied in the thin juice samples. For the genetic variability, considering both years, the number of different characters studied in thin juice samples are 7. Probably the number should be increased to 8 as percentage sucrose and percentage apparent purity are somewhat closely associated in both years as regards the genetic variability. This does not mean that in any given segregating population the least number of genes differentiating any given population is 8. For example, hybrid populations derived by hybridizing closely related inbreds could be segregating for only one or a few of the genes differentiating one of the chemical characters. Going to the other extreme, segregating populations derived from very diverse genetic material would be expected to have many more than eight gene pairs differentiating percentage sucrose and differentiating percentage apparent purity. Undoubtedly, genetic linkages both favorable and unfavorable to the recombination of genes tending to produce higher percentages of sucrose and to the recombination of genes tending to produce higher percentages of purity are occurring in the transmission of genes in these segregating populations derived from hybridization of extremely diverse genetic material.

Such being the case, it seems highly improbable that the populations being grown commercially today have obtained the maximum possible as regards either percentage sucrose or percentage apparent purity. It is still more improbable that the populations being grown commercially today have obtained the maximum possible in recombining high weight per root, high percentage sucrose, and high percentage apparent purity. Some of the researches promising the greatest remuneration to the beet sugar industry

involves fundamental studies on the genetics of and methods of breeding for these three characters.

In any breeding program, criteria for selection are important and the expense of the breeding program can be reduced materially if the number of characters used as criteria for evaluating individual plants, populations, inbreds, etc., can be reduced. The closeness of the association between percentage sucrose and percentage apparent purity with each other and with total nitrogen and betaine in the thin juice indicates that perhaps either of the latter would be a rather effective criterion for use in breeding populations having higher percentages of sucrose and higher percentages of apparent purity. Of course the ideal would be to use all four characters as criteria for evaluating material to be used in breeding programs for improving percentage sucrose and percentage apparent purity of populations grown for the production of beet sugar.

Phenotypic-Dominance Phenomena

Phenotypic-dominance phenomena can be determined for weight per root, percentage sucrose, percentage apparent purity, and the concentration of the chemicals determined from an analysis of the thin juice and those determined from an analysis of the petioles.

The F_1 hybrid grown in 1956 exhibits heterosis for weight per root, percentage sucrose, and percentage apparent purity. Heterosis for weight per root was expected. That is, the F_1 was expected to possess hybrid vigor. That the F_1 would also exceed either parent in both percentage sucrose and percentage apparent purity was not expected, and undoubtedly is true of only certain hybrids. In the thin juice, total nitrogen, betaine, potassium, and sodium ranged in expression of the character from minus partial dominance to minus heterosis. Only glutamic acid exhibited plus dominance and this was for the fertilized plots. Since a decrease in all of those chemical characters in the thin juice, both as regards environmental and genetic variability, tends to be associated with an increase in both percentage sucrose and percentage apparent purity, it is apparent that the dominance phenomena exhibited by the F_1 for total nitrogen, betaine, potassium, and sodium in the thin juice are favorable. They would be conducive to expression of heterosis for higher sucrose and higher purity as actually was found to be the case for this F_1. The plus dominance noted for glutamic acid would tend to offset, somewhat, these favorable dominance reactions noted for the other chemical characters measured in the thin juice. It is interesting to note that nitrate nitrogen in the petioles on the fertilized plots is intermediate but that all the other chemical characters measured in the petioles exhibit minus partial dominance. It is apparent that, in general, the dominance phenomena shown by the chemical characters studied for this hybrid on the fertilized plots are favorable to both high percentage purity and to high percentage sucrose. This would indicate that by employing those methods of breeding designed to utilize heterosis, hybrid populations can be bred that are superior in weight per root, percentage sucrose, and percentage apparent purity to those varieties now grown for the manufacture of beet sugar.

Heterosis, dominance, partial dominance, and intermediate dominance are different degrees of expression of a given character due to physiological-genetic reactions and interactions (Powers 8). That the expression of dominance is dependent upon both the genotype and environment has been demonstrated by a number of workers (Goldschmidt 4); and that dominance may be shifted to heterosis,or vice versa, by varying either the genotype or the environment has been shown by Powers (7). The data in tables 6 and 7 substantiate these deductions. Then in summary it may be said that heterosis and dominance are different degrees of expression of the same physiological-genetic phenomena and are dependent upon both the genotype and environment and upon the interactions within and between them. Also,these studies emphasize the importance of the chemical characters and their interrelations in determining the phenotypic-dominance reactions of weight per root, percentage sucrose, and percentage apparent purity. In turn, these findings have a very practical application in breeding superior populations for use in the production of beet sugar.

Combining Ability and Dates of Harvest Tests

It was found from a study of the 1956 data that the two hybrid populations compared with a commercial variety, A54-1, showed no decrease in percentage sucrose or very little decrease when grown on the fertilized plots, as compared with the non-fertilized. A54-1, however, showed a decrease in percentage sucrose when grown on the fertilized plots. The replication groups in this experiment varied considerably in nitrogen fertility level. This was shown by concentrations of nitrate nitrogen in the petioles. For A54-1 (see 9 table 8), the replication groups varied from 829 parts per million of nitrate nitrogen in the petioles to 13,778 on the fertilized plots. The range was similar for the other populations. The range for A54-1 on the non-fertilized plots was from 452 parts per million of nitrate nitrogen in the petioles to 6055. Such being the situation, an opportunity was provided to determine whether some populations, as regards these replication groups, are able to reach, simultaneously, the maximum mean sucrose content and maximum mean weight per root, whereas other populations are not able to do so. The data for populations A54-1, 50-406BB, and the F_1 (50-406 X 52-307) are taken from table 12.

The maximum mean weight per root of A54-1 for any of the replication groups was 2.90 pounds and the corresponding mean sucrose content was 17.1 percent. The maximum sucrose content was 18.4 percent and the corresponding weight per root was 1.66. Hence, maximum weight per root is accompanied by a comparative decrease in percentage sucrose.

For 50-406BB, the maximum mean weight per root for any of the replication groups was 2.24 pounds and the mean sucrose content was 18.1 percent. The maximum mean percent sucrose content was 18.0 on the non-fertilized plots and the mean weight per root was 1.43 pounds. It is apparent that for this

top-cross hybrid and under the conditions of this experiment, maximum mean weight per root and maximum mean percentage sucrose occur together. It will be recalled that this top-cross, hybrid 50-406BB, had a higher concentration of total nitrogen in the thin juice as compared with the inbred parent but that this higher concentration was not accompanied by a material reduction in percentage sucrose.

The maximum weight per root for the F_1 hybrid was 2.49 pounds and the corresponding percent sucrose for this replication group was 18.5, which was also the maximum percent sucrose of any of the replication groups either on the fertilized or non-fertilized plots. The maximum percent sucrose on the non-fertilized plots was 18.3 and the corresponding weight per root was 1.39 pounds. Hence, the maximum weight per root and the maximum percentage sucrose occur in the same replication group on the fertilized plots. It will be recalled that the F_1 hybrid had a concentration of only 21.3 milligrams per 100 milliliters of thin juice of total nitrogen as compared with a concentration of 46.8 for A54-1 grown under the same fertilizer treatment (fertilized plots).

For these replication groups giving the maximum weights per root, the concentrations of total nitrogen in the thin juice are 38.6, 25.7, and 17.8, respectively, for A54-1, 50-406BB, and the F_1. The corresponding parts per million of nitrate nitrogen in the petioles are 1724, 1050, and 390, and the corresponding apparent purities are 94.2, 95.3, and 95.5. These comparisons are for the fertilized plots. Considering both the fertilized and the non-fertilized plots, the apparent purities decrease with an increase in total nitrogen in the thin juice from 97.8, which has 8.8 milligrams of nitrogen per 100 milliliters of thin juice, to 94.2 which has 38.6 milligrams. It is apparent that percentage apparent purity is closely associated with total nitrogen in the thin juice and that comparative improvement in apparent purity is found in those populations which have less total nitrogen in the thin juice. These favorably reacting populations are the hybrids of table 12. That the higher percentage purities would be found in hybrid populations would have been expected from the phenotypic-dominance phenomena of the chemical characters of the thin juice listed in tables 6 and 7.

It is clear that the breeder can do much to improve both percentage sucrose and percentage apparent purity. The improvement in percentage sucrose will result from the fact that, for certain hybrids, higher concentrations of nitrogen in the thin juice up to certain limits is not accompanied by a reduction in sucrose content and to the fact, that certain hybrids have a lower concentration of total nitrogen in the thin juice as compared with other populations under the same fertilizer practices. The increase in percentage apparent purity is associated with the latter phenomenon; that is, some populations have less total nitrogen in the thin juice than other populations.

These findings raise the question as to whether populations (genotypes) might not differ as to the length of the growing season required to obtain

acceptable percentages of sucrose and weights per root. In 1961, an experiment was conducted to determine whether such might be the case. The data are taken from table 13.

The data on weight per root show that, undoubtedly, there are four levels of yield represented by the four populations. The F_1 hybrid 52-430 X 52-408 averages 6.2 percent lower weight per plot than does the commercial variety. The yields of all populations increased from September 14 to October 3, but none of the population yields increased after October 3.

The data for percentage sucrose reveal that, when harvested September 14, all of the F_1 hybrids have from 1.9 to 3.0 percent more sucrose than does A56-3, the commercial variety with which they are compared. Moreover, all of the hybrids had higher percentage sucrose harvested on September 14 than did the commercial variety harvested on October 3, and the sucrose content of 52-430 X 54-565 was significantly higher than that of A56-3. In fact, this hybrid had as high a percentage sucrose content harvested on September 14 as did the commercial variety harvested on October 16. Likewise, all of the hybrids had higher percentages sucrose content harvested on October 3 than did the commercial variety harvested on October 16. In the case of the first two hybrids listed, they averaged about 1 percent higher sucrose harvested on October 3 than did the commercial variety harvested on October 16. Finally, the F_1 hybrids harvested on October 16 had from 1.5 percent to 2.5 percent higher sucrose than did the commercial variety. It is clear that hybrid populations can be obtained that will have as high a percentage sucrose as this commercial variety when harvested from two weeks to one month earlier.

A study of the data for yield of sugar per plot reveals that hybrid 52-430 X 52-408 produces more sugar per plot for all 3 dates of harvest than does the commercial variety, and the difference for September 14 approaches statistical significance. Moreover, this hybrid harvested on September 14 produced within 9 percent as much sugar per plot as did the commercial variety harvested on October 3 and within 15 percent as much sugar per plot as did the commercial variety harvested on October 16, approximately one month later. Hybrid 52-430 X 52-408 harvested on October 3 produced within 4 percent as much sugar as did the commercial variety harvested on October 16. The importance of this behavior of F_1 hybrids lies in the fact that by growing them, the beet sugar factories can be operated over a longer period of time. By longer operation of the factories fewer beets would be piled and storage losses would be reduced materially. The production of hybrids that can be harvested from a month to two weeks earlier would also reduce, considerably, the expense of harvesting beets, as by growing such hybrids the farmer would have more choice of the conditions under which the harvest would be conducted. Consequently, unfavorable weather conditions could be avoided, particularly those occurring late in the fall.

The fact that the hybrids studied in these researches do not have as great a weight per root as the commercial variety raised the problem whether

the physiological relations between weight per root, percentage sucrose, and percentage apparent purity are such that hybrid populations cannot be obtained that will exceed the commercial variety in all three characters.

In 1960, an experiment was conducted that provided information as to such a physiological possibility. A54-1 and the F_1 hybrid 52-430 X 52-307 were grown in this study. The data are taken from table 14. It is readily apparent from the data listed in this table that the F_1 hybrid exceeds the commercial variety in weight per root, percentage sucrose, and percentage apparent purity. This does not prove that this F_1 hybrid will be superior in all three of these important agronomic characters under all environmental conditions,but it does prove that increases in all three of these characters can be obtained simultaneously. This experiment was conducted on plots all of which had received an application of 100 pounds of N and 250 pounds of P_2O_5.

These results could have been predicted from the chemical-genetic studies summarized in this article. That is, the genotype-environmental interactions, the associations of characters as regards both the environmental and genetic variability, and the phenotypic-dominance phenomena are more favorable on the average for certain hybrid populations.

Perhaps the most important findings from these researches are that certain hybrid populations are more likely to have higher percentage sucrose and higher percentage apparent purity over a wider range of environmental conditions than are commercial varieties. That is, they would be expected to perform more favorably over a period of years, over diverse climatic conditions represented by locations, and under different fertilizer and other cultural practices. This is indicated by the following findings. First, there is a close negative association between total nitrogen in the thin juice and the nitrogenous compounds and both higher percentage sucrose and higher percentage apparent purity. Second, some genotypes (populations) have higher percentage sucrose associated with higher levels of total nitrogen in the thin juice than do some of our commercial varieties. Finally, some F_1 hybrids under conditions conducive to high nitrogen in the thin juice do not have as high a concentration of nitrogen in the thin juice as some of the commercial varieties. Other chemical characters showed behavior patterns similar to those discussed previously in this paragraph.

These findings led to the postulation that some F_1 hybrids would have higher percentage sucrose at different dates of harvest than the commercial variety and such was found to be the case. One hybrid harvested on September 14 had 0.3 percent higher sucrose than did the commercial variety on October 16. These results show that by growing certain hybrids the number of poor quality years would become less frequent. Moreover, when they did occur quality would not be as poor as it would have been if the old commercial varieties had been grown. Equally, if not more important is the fact that the hybrids would be expected to yield higher quality beets over a wider range of soil and climatic conditions.

Summary

1. The most important agronomic characters studied were weight per root, percentage sucrose, and percentage apparent purity. Characters studied in the thin juice were total nitrogen, glutamic acid, betaine, potassium, sodium, and chlorides. Characters studied in the petioles were nitrate nitrogen, phosphorus, potassium and sodium. These make a total of 13 characters.

2. Primarily, this article is concerned with the interrelations of the characters as determined by a study of the means and simple correlation coefficients, with phenotypic-dominance phenomena and with dates of harvest and combining ability tests.

3. The variabilities studied were those attributable to environmental differences and those attributable to genetic differences.

4. As regards the environmental variability, weight per root, percentage sucrose and percentage apparent purity are very closely associated with each other and with total nitrogen, glutamic acid, and betaine in the thin juice and with phosphorus and sodium in the petioles. Weight per root is negatively associated with sucrose, purity, phosphorus, and potassium in the petioles. It is positively associated with total nitrogen, glutamic acid, and betaine in the thin juice and nitrate nitrogen and sodium in the petioles. Sucrose and purity are very closely associated with each other and with concentrations of phosphorus in the petioles. The associations are positive. Also, sucrose and purity are very closely associated with nitrogen, the nitrogenous compounds and sodium in the thin juice, but the associations are negative.

5. As regards the environmental variability, total nitrogen, glutamic acid, and betaine in the thin juice and nitrate nitrogen and sodium in the petioles are closely associated with each other. The associations are positive. They are negatively associated with phosphorus and potassium, the association with phosphorus being close.

6. Phosphorus and potassium in the petioles are positively associated with each other. However, the association is not close, only 6 percent of the environmental variability of one being accounted for by that of the other.

7. For the environmental variability, nitrate nitrogen and sodium in the petioles were found to form one behavior pattern as regards their associations with all other characters and with each other, and phosphorus and potassium in the petioles another behavior pattern. All of the characters with which nitrate nitrogen and sodium are associated positively, phosphorus and potassium are associated with negatively. Further, all the characters with which nitrate nitrogen and sodium are associated with negatively, phosphorus and potassium are associated with positively. For these studies, increases in total nitrogen were

accompanied by marked increases in weight per root up to concentrations of 46.8 milligrams per 100 milliliters of thin juice. However, increases in concentrations of total nitrogen were not accompanied by increases in weight per root above a value lying somewhere between 46.8 and 62.9 milligrams per 100 milliliters of thin juice.

9. Both percentage sucrose and percentage apparent purity, as regards the environmental variability, continued to decrease with an increase in concentration of total nitrogen in the thin juice. In going from 18.8 mg of total nitrogen in the thin juice to 103.5 mg the accompanying decrease in sucrose was 4.9 percent (from 17.9 to 13.0) and the accompanying decrease in percentage apparent purity was 13.4 percent (from 96.1 to 82.7).

10. It is apparent that under the environmental conditions of this experiment excess applications of nitrogen fertilizer are not accompanied by increases in yields of roots but are accompanied by material reductions in both percentages of sucrose and percentages of purity.

11. For 1956 data, the genetic variability was studied on the basis of the two fertilizer treatments, non-fertilized and fertilized. With a few exceptions, the characters are not nearly so closely associated as they are for the environmental variability. The only somewhat close associations for weight per root occur on the non-fertilized plots and are with percentage sucrose and with nitrate nitrogen in the petioles. The relation is positive. The only very close association for sucrose is with betaine on the fertilized plots and the relation is negative. The only very close associations for percentage apparent purity are with betaine and potassium in the thin juice. The relations are negative and are for the fertilized plots. The associations between purity and sucrose and purity and total nitrogen in the thin juice are also somewhat close, being positive in the first case and negative in the second. Also, it should be noted that purity is negatively associated with all the other five characters of the thin juice.

12. The associations between total nitrogen in the thin juice, glutamic acid, and potassium in the thin juice are very close on both the fertilized and non-fertilized plots. The relations are positive.

13. As regards genetic associations with other characters potassium and sodium in the thin juice follow very similar behavior patterns, excepting the associations with phosphorus and potassium in the petioles, and therefore will be discussed together. The only significant negative associations, except as noted below, are with purity on both the non-fertilized and fertilized plots and with percentage sucrose on the fertilized plots. The associations of potassium in the thin juice with phosphorus and potassium in the petioles on the fertilized plots are negative also, whereas the associations of sodium in the thin juice with these same characters are positive. It is interesting to note that potassium in the thin juice is negatively associated with potassium

in the petioles; whereas, sodium in the thin juice is very closely associated with sodium in the petioles and the relation is positive.

14. As was noted for the environmental variability, nitrate nitrogen and sodium in the petioles as regards the genetic variability for 1956 follow one behavior pattern and phosphorus and potassium in the petioles another. The behavior patterns are not as marked for the genetic variability as they were for the environmental variability. For example sodium in the petioles is positively associated with phosphorus and potassium in the petioles, and the correlation coefficients are statistically significant at the 5-percent level. Also, the associations of nitrate nitrogen with these same two characters are positive, but they are negligible. Not only are phosphorus and potassium following very similar behavior patterns, as regards their association with other characters, but they are very closely associated with each other, 79 and 92 percents of the variance of one being accounted for by that of the other on the non-fertilized and fertilized plots, respectively.

15. The 1958 data pertaining to relations between characters determined from a study of the genetic variability become more meaningful when compared with the corresponding 1956 data.

16. In 1958, weight per root is negatively associated with total nitrogen in the thin juice, whereas in 1956 the association is positive. It is clear that the populations grown in 1958 are not behaving the same as the populations grown in 1956 as regards the relation between weight per root and total nitrogen in the thin juice.

17. The data for both 1958 and for 1956 on the fertilized plots show that percentages sucrose and percentages apparent purity are negatively associated with total nitrogen in the thin juice. In 1958 both of these characters are positively associated with phosphorus and potassium in the petioles and negatively associated with sodium in the petioles. As regards the genetic variability in 1956 sucrose is negatively associated with phosphorus and potassium in the petioles and the relation with sodium is negligible.

18. For 1958 total nitrogen in the thin juice is negatively associated with nitrate nitrogen, phosphorus, and potassium in the petioles and positively associated with sodium. However, the association with sodium is negligible. The association of total nitrogen in the thin juice and nitrate nitrogen in the petioles is the opposite of that for these same two characters in 1956, as regards the genetic variability. It must be kept in mind that the populations which provide the differences giving rise to the genetic variability are not the same for the two years.

19. Nitrate nitrogen in 1958 is very closely associated with potassium in the petioles and to a smaller degree with sodium. The associations of nitrate nitrogen with phosphorus are negligible in both 1958 and 1956. Also, the association with potassium is negligible in 1956.

20. For the genetic variability, phosphorus and potassium in the petioles are positively associated in both 1958 and 1956, the association being negligible in 1958 and very close in 1956. It must be kept in mind that the populations differed for the two years. Phosphorus and sodium are negatively associated in 1958 and positively associated in 1956. Potassium and sodium are positively associated in both years and to about the same degree.

21. Considering all of the associations studied, both environmental and genetic, the most consistent relations involving percentage sucrose and percentage apparent purity are those with each other and those with total nitrogen and betaine in the thin juice. With each other the associations are positive and with total nitrogen and betaine the associations are negative. For the environmental variability the degree of association is very high, the least amount of the variability accounted for by regression being 94 percent. For the genetic variability in 1956 the association between sucrose and total nitrogen is negligible on the fertilized plots. The same is true of sucrose and betaine in 1958. This indicates that some populations produce higher percentage sucrose at the same or higher concentrations of total nitrogen and betaine in the thin juice than do other populations. Such was found to be the case. The same was found to be true as regards purity with total nitrogen and betaine.

22. Also, it was found that some populations had as low concentrations of total nitrogen in the thin juice on the fertilized plots as other populations had on the non-fertilized plots. Further, for such populations there was no material reduction in the percentages of sucrose in going from the non-fertilized to the fertilized plots.

23. It was found that relative concentrations of nitrate nitrogen in the petioles could not always be taken as an indication of relative concentrations of total nitrogen in the thin juice. For example, 55-5307 grown in 1958 has the lowest concentration (2865 ppm) of nitrate nitrogen in the petioles and the highest concentration (116.4 mg) of total nitrogen in the thin juice; whereas, A56-5BB has the highest concentration (6240 ppm) of nitrate nitrogen in the petioles and the lowest concentration (71.2 mg) of total nitrogen in the thin juice. This was not a lone case as similar behavior patterns were found for populations grown in 1956. This finding has an important bearing on the breeding of high quality sugar beets. It means that populations can be bred which have comparatively higher concentrations of total nitrogen in the thin juice without a material reduction of percentage sucrose as compared with other populations. It will be recalled that total nitrogen in the thin juice is very closely associated with higher percentages of apparent purity.

24. Also, it was found that relative concentrations of potassium in the petioles cannot always be taken as an indication of relative concentrations of potassium in the thin juice. For example, 52-307 had 24690 ppm of potassium in the petioles and only 99.4 parts per 100,000 of

potassium in the thin juice; whereas A54-1 had 17695 ppm of potassium in the petioles and 133.1 parts per 100,000 of potassium in the thin juice. This genetically controlled decrease of 133.1 to 99.4 parts per 100,000 of potassium in the thin juice was accompanied by an increase of 1.7 percent in purity.

25. It was found that relative concentrations of sodium in the petioles was a fairly reliable indicator of relative concentrations of sodium in the thin juice.

26. With the exception of glutamic acid on the fertilized plots in 1956, it was found that the phenotypic-dominance phenomena of the chemical characters in the thin juice are favorable to both higher percentage sucrose and higher percentage apparent purity. That is the F_1 as compared to the two inbreds showed partial dominance, complete dominance, or heterosis for lower concentrations of the respective chemical in the thin juice. This was true for both of the F_1 hybrids grown in the two different years.

27. These results involving studies of the genetic variability and phenotypic dominance phenomena indicate that it is possible to breed hybrids that have higher percentages of sucrose than our better commercial varieties at earlier dates of harvest. Such was found to be the case. One hybrid had as high percentage sucrose when harvested on September 14, 1961, as did A56-3, a commercial variety, when harvested on October 16, approximately one month later. None of the F_1 hybrids were equal to A56-3 in yield of roots, but one was fully the equal of A56-3 in yield of sugar per plot.

28. The studies reported in this article indicate that it should be possible to breed hybrid populations that are superior to A56-3 in weight per root, percentage sucrose, and percentage apparent purity. Such was found to be the case for one hybrid grown in 1960. It surpassed A56-3 in all three characters and the differences were statistically significant.

29. From these studies it is apparent that to obtain maximum returns for both the farmer and the processor of beet sugar, populations of sugar beets adapted to production at higher fertility levels and adapted to other environmental conditions, such as different climates and locations, must be bred. If the maximum returns are to be realized, proper fertilizer and other cultural practices must be followed in growing of these superior populations of sugar beets. It does not seem likely, if at all possible, that populations, hybrids or otherwise, can be bred that will produce satisfactory percentages of sucrose and satisfactory percentages of apparent purity when indiscriminate use of nitrogenous fertilizers is practiced. It seems almost certain that the populations grown in the future to produce beet sugar will be varieties or hybrids bred to take advantage of the favorable phenotypic-dominance phenomena found in these studies to be occurring.

Literature Cited

(1) Arnon, D. I., 1953. The physiology and biochemistry of phosphorus in green plants. Soil and fertilizer phosphorus. Edited by W. H. Pierre and A. G. Norman. 492 pp, illus. Academic Press, New York.

(2) Crafts, A. S., 1961. Translocation in plants. 182 pp, illus. Holt, Rinehart, and Winston. New York.

(3) Federer, W. T., Powers, LeRoy, and Payne, Merle G. In process of publication. Studies on statistical procedures applied to chemical genetic data from sugar beets.

(4) Goldschmidt, Richard, 1938. Physiological genetics. 375 pp, illus. McGraw-Hill. New York and London.

(5) Payne, Merle G., Powers, LeRoy, and Maag, Grace W., 1959. Population genetic studies on the total nitrogen in sugar beets (*Beta vulgaris* L.). Jour. Amer. Soc. Sugar Beet Tech. X(7): 631-646.

(6) Payne, Merle G., Powers, LeRoy, and Remmenga, E. E. In press. Some chemical-genetic studies pertaining to quality in sugar beets (*Beta vulgaris* L.).

(7) Powers, LeRoy, 1941. Inheritance of quantitative characters in crosses involving two species of *Lycopersicon*. Jour. Agr. Res. 63: 149-174.

(8) Powers, LeRoy, 1944. An expansion of Jones's theory for the explanation of heterosis. Amer. Nat. 78: 275-280.

(9) Powers, LeRoy, Robertson, D. W., and Clark, A. G., 1958. Estimation by the partitioning method of the numbers and proportions of genetic deviates in certain classes of frequency distributions. Jour. Amer. Soc. Sugar Beet Tech. IX(8): 677-696.

(10) Powers, LeRoy, Robertson, D. W., and Remmenga, E. E., 1958. Estimation of the environmental variances and testing reliability of residual variances for weight per root in sugar beets. Jour. Amer. Soc. Sugar Beet Tech. IX(8): 697-708.

(11) Powers, LeRoy, Robertson, D. W., Whitney, R. S., and Schmehl, W. R., 1958. Population genetic studies with sugar beets (*Beta vulgaris* L.) at different levels of soil fertility. Jour. Amer. Soc. Sugar Beet Tech. IX(8): 637-676.

RELATIONSHIPS OF WEIGHT PER ROOT WITH FIVE CHEMICAL CHARACTERS IN SUGAR BEETS[1,2,3,4]

The purpose of this study is to investigate methods of elucidating interrelationships of dependent and independent variables and describing their mutual response within populations of sugar beets as they are affected by their environment. Hence, the variability studied is primarily environmental, involving differences between replications within populations and differences between fertilizer treatments.

1/ Cooperative investigations of the Colorado Agricultural Experiment Station, the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Beet Sugar Development Foundation. The Colorado State University gratefully acknowledges financial support from the James G. Boswell Foundation administered by the Agricultural Research Center of Stanford Research Institute, the National Institutes of Health, and the Beet Sugar Development Foundation and contract-research-funds from the Agricultural Research Service of the U. S. Department of Agriculture. These studies would not have been possible if these funds had not been granted.

2/ The writers are indebted to R. Ralph Wood of the Great Western Sugar Company for obtaining thin juice samples by an oxalate method standard with his company and also acknowledge the cooperation of D. W. Robertson, Robert S. Whitney, and W. R. Schmehl in conducting the field experiment. The writers are indebted to the Western Data Processing Center at the University of California at Los Angeles for use of the computing facilities for analyzing data.

3/ This portion of the report is taken from an article in process of preparation for publication by Richard J. Hecker, W. T. Federer, M. G. Payne, and LeRoy Powers.

4/ This portion of the report was prepared by Richard J. Hecker.

Materials and Methods

From previous work with the 1956 population genetics study conducted at this station by Dr. LeRoy Powers it was decided to investigate further the environmental relationships of weight per root (Y) with the following five chemical characters of the thin juice:

X_1 = total nitrogen

X_2 = sodium

X_3 = potassium

X_4 = glutamic acid

X_5 = betaine

Total nitrogen, glutamic acid, and betaine are expressed in milligrams per 100 milliliters of thin juice equated to a refractometer reading of ten. Sodium and potassium are expressed in parts per 100,000. The design and details of the experiment have been thoroughly discussed in other papers, particularly Powers, Robertson, Whitney, and Schmehl (3). Briefly, the experiment consisted of six populations (three segregating and three non-segregating), two nitrogen fertility levels, and 40 replications under each treatment. This report considers only weight per root as a dependent variable. It will later be expanded to include the dependent variables percentage sucrose and percentage apparent purity.

Based on the environmental interrelationships of root weight and the above chemical characters, threshold values for the independent variables (X_i) are of primary interest, principally agronomic or applied in nature. These threshold values define the points in the n-dimensional space, in terms of the independent variables (X_i), at which the dependent variable (Y), weight per root, reaches its maximum. In the interest of clarity the five chemical characters will be referred to in this study as being independent variables; independent, that is, of weight per root. From the nature of the characters under consideration it is not clear that they are completely independent of root weight and they are not likely to be completely independent of each other. However, this is not expected to affect unduly the biological interpretations.

If one were able to generate a mathematical model which fully described the response function of Y and the X_i, then one would also be able to accurately predict the values for X_i which would produce the maximum Y if one exists. Of course it is not conceivable that a mathematical model could be developed which would account for 100 percent of the variability in Y, but perhaps models could be found which might account for an important part of

the total variability. If so, one may be able to predict with some satisfactory degree of accuracy the values for X_i which would produce the maximum Y. This could then lead through management and breeding practices to regulation of the independent variables in achieving this maximum Y. Certain of the independent variables of the economically important characters in sugar beets are regulatable both through breeding and cultural practice, as has been demonstrated previously in work at this station and by others.

In this study two mathematical models are considered in an attempt to describe the response function of weight per root (Y) on the five independent variables (X_i) listed above. The two polynomial multiple regression models are used in estimating corresponding threshold values. Comparisons are also made between the multiple correlation coefficients and the simple correlation coefficients. These comparisons are made on among-plot correlations and regressions both within treatments and over treatments. By using among-plot relationships the primary emphasis of this study is on environmental aspects, although certain genetic aspects (differences between populations) are considered. These among-plot relationships are calculated using plot totals. Plot means could also be used.

The first of the two models considered is a quadratic multiple regression model of the form:

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + c_1 X_1^2 + c_2 X_2^2 + c_3 X_3^2 + c_4 X_4^2 + c_5 X_5^2 . \qquad [1]$$

Interaction terms such as $X_1 X_2$, $X_1 X_2^2$, etc., could also be included in this regression model. However, a preliminary examination of the data and the biological considerations indicated that this additional refinement was unnecessary.

The estimated values for X_i (i.e., $\hat{X}_1$, $\hat{X}_2$, $\hat{X}_3$, $\hat{X}_4$, $\hat{X}_5$) at which the maximum (or minimum) Y value is obtained is calculated by differentiating the multiple regression equation in [1] with respect to each X_i, setting the resulting derivatives equal to zero, and then solving for X_i in terms of the regression coefficients. Thus, in general from the estimated value for X_i yielding a maximum Y is obtained from the formula:

$$\hat{X}_i = \frac{-b_i}{2c_i} \qquad [2]$$

The conficence interval for X_i at the $1 - \alpha$ significance level is developed from Kenney and Keeping, Part 2, (p. 337) (1) and is found by

solving for the roots of the following quadratic equation in λ:

$$\lambda^2 (4t_\alpha^2 s^2 a^{22} - 4 c_i^2) + \lambda(4t_\alpha^2 s^2 a^{12} - 4 b_i c_i) + (t_\alpha^2 s^2 a^{11} - b_i^2) = 0 \qquad [3]$$

where t is Student's t at the desired significance level, s^2 is the variance of the estimate from the multiple regression analysis, a^{ij} is the respective element of the inverse matrix in the regression analysis, and b_i and c_i are regression coefficients from the multiple regression equation [1].

Since the quadratic multiple regression model, equation [1], can result in non-realistic values for the estimated threshold values (i.e., negative values for $\hat{X}_i$ or extremely large values for $\hat{X}_i$), a second mathematical model is considered. Based on biological grounds it is not unreasonable to consider that:

$$Y_j = a_i X_{ij}^{b_i} e^{c_i X_{ij} + \epsilon_{ij}} \qquad [4]$$

where e is the Napierian base 2.71828 . . . . In fact from an examination of the distribution of the data this exponential model would seem to fit the biological situation being considered more realistically than the quadratic model, particularly when considering percentage sucrose and percentage apparent purity. For $X_{ij} \geq 0$, $b_i > 0$, and $c_i < 0$, the above function is bounded on the left by zero and it approaches zero as the value of X_{ij} becomes large. For example, in a two-dimensional space the function is being forced through the origin on the left and is made asymptotic to the X axis on the right. Certainly, it is reasonable to assume that if any of the X_i being considered in this study were at zero there would be no root. Also, with increasing amounts of any X_i above the optimum, root weight would be expected to decrease and finally approach zero even though this optimum point may be beyond any achievable root yield. When $b_i < 0$ and/or $c_i > 0$ the function in general has no maximum.

Although this function should tend to locate more realistically the estimates of the points at which the maxima occur in the six-dimensional space under consideration in this study, it is not known that the following predictive equation for the five chemical characters has a sound biological basis:

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} e^{c_1X_1+c_2X_2+c_3X_3+c_4X_4+c_5X_5} \qquad [5]$$

In other words it is not known whether the variables really act in a multiplicative manner or whether their action is additive, as in the quadratic model, or a combination of additive and multiplicative action, or any of a host of scales on which they may perform. It cannot be hoped that a mathematical model will duplicate the action within the plant, but the model may approximate its end result.

The estimated value for X_i resulting in a maximum value of Y for this exponential model is:

$$\hat{X}_i = \frac{-b_i}{c_i} \qquad [6]$$

This equation is obtained by differentiating the equation in [5] with respect to each X_i, setting the resulting derivatives equal to zero, and then solving for X_i in terms of the regression coefficients.

The confidence interval for $\hat{X}_i$ in [6] is developed in an analogous manner to that of equation [3]. The interval formula is just twice that of equation [3].

As in the quadratic model, interaction terms could be included in this exponential model but the significance of such terms is not clear. The meaningfulness of any term should be evaluated before it is included in the model.

When equation [5] is converted to natural log form so that it may be treated by least squares it takes the following form:

$$\log Y = a' + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + c_1 X_1 + c_2 X_2 + c_3 X_3 + c_4 X_4 + c_5 X_5 \qquad [7]$$

where $a' = \log a$. This in no way changes the estimated threshold values from equation [6].

Other models could be developed which might be of interest, but the justification for using any regression model must come from biological considerations. There does appear to be a biological basis for a curvilinear relationship of these five thin juice chemical characters (X_1, X_2, X_3, X_4, and X_5) with the economically important character weight per root (Y). The quadratic and exponential relationships used in this study were considered as approximations to the true form of the response curve.

It should be noted that even though the range in the chemical char-

acters was wide enough to permit this study, insufficient low values were obtained to fully investigate the form of the response curve in certain populations. The low values necessary would be below those found in commercial fields of sugar beets. It should be further noted that without the relatively large number of replicates used for the 1956 experiment and without the relatively large differences in replicates, this study would have been impossible. The fact that the last group of replicates differed widely from the rest [see Powers, Robertson, Whitney, and Schmehl (1958), table 8] (3) and the fact that two fertilizer treatments were included was of paramount importance to a study of this nature. Also, the inclusion of two fertilizer treatments was a necessity to obtain a greater range in the characters measured.

Results

The regression model given by equation [1] was applied to the 1956 data for weight per root with the five chemical characters nitrogen (X_1), sodium (X_2), potassium (X_3), glutamic acid (X_4), and betaine (X_5) for each of the six populations over treatments. The partial regression coefficients and their standard errors using the 80 plot totals are given in table 1. As regards the populations, A54-1 is a commercial variety, A54-1BB is a broad base population resulting from A54-1 being used as a female parent with 22 other pollinators, 50-406BB was developed in the same manner with the inbred 50-406 being used as the female parent, 50-406 and 52-307 are inbreds, and the F_1 hybrid resulted from crossing these two inbreds.

In table 2 a comparison is made of the simple correlation coefficients squared, and the multiple correlation coefficients squared for the five chemical characters and their squares with weight per root for each population among plots. Also included in table 2 are the threshold values of the five characters for maximum weight per root and the means of the plot totals over treatments and within populations. The threshold estimates are calculated from equation [2]. These estimates are designated in the tables as $\hat{X}_{max}$. It will be found that these estimates do not always correspond exactly with estimates calculated directly from table 1. This is due to the rounding off of the regression coefficients in table 1. It was necessary to use the original eight decimal regression coefficients in calculating the threshold estimates to avoid division by zero in a few cases. Also this is the case in tables 4 and 6.

Table 1 Partial regression coefficients and their standard errors for the six populations using 80 plot totals in regression equation [1].

Population	Statistic	Character									
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
A54-1	partial b	0.017837	0.010070	0.014764	0.007557	0.021105	-0.000016	-0.000015	-0.000002	-0.000004	-0.000014
	s_b	0.020751	0.008543	0.023242	0.006153	0.024489	0.000027	0.000009	0.000011	0.000005	0.000015
A54-1BB	partial b	0.080373*	-0.001944	-0.023813	0.007816	0.030469*	-0.000100*	-0.000002	0.000014	-0.000009	-0.000020*
	s_b	0.018087	0.008950	0.026249	0.008137	0.007623	0.000024	0.000012	0.000013	0.000010	0.000005
F_1 hybrid	partial b	0.053492	0.009835	0.094587	-0.012970	0.011771	-0.000119	-0.000018	-0.000053	0.000026	-0.000002
	s_b	0.036800	0.007227	0.049469	0.013749	0.010138	0.000084	0.000012	0.000030	0.000030	0.000008
50-406	partial b	0.040542	0.001055	-0.005971	-0.003204	0.001582	-0.000085	-0.000010	0.000003	0.000019	0.000000
	s_b	0.021238	0.007893	0.023274	0.004843	0.007235	0.000045	0.000014	0.000012	0.000010	0.000004
50-406BB	partial b	0.116938*	-0.013175	-0.025187	-0.022478*	0.000747	-0.000174*	0.000012	0.000015	0.000022*	-0.000000
	s_b	0.022906	0.007932	0.032939	0.006203	0.002713	0.000051	0.000014	0.000019	0.000007	0.000000
52-307	partial b	-0.015190	0.018231*	0.016218	-0.005820	0.015247	0.000120	-0.000024*	-0.000015	0.000000	-0.000005
	s_b	0.031811	0.006406	0.048834	0.011457	0.011794	0.000100	0.000009	0.000029	0.000000	0.000008

* Denotes that the partial regression coefficient is significantly greater than zero at the five percent level.

Table 2 Simple correlation coefficients squared, multiple correlation coefficients squared, estimated threshold values for maximum root weight, and means of plot totals for five chemical characters using regression equation [1].

Population	Statistic	Character (among 80 plots)					R^2
		X_1	X_2	X_3	X_4	X_5	
A54-1							0.617
	r^2	0.355	0.226	0.289	0.365	0.392	
	$\hat{X}_{max}$	557.406	335.667	3691.000	944.625	753.750	
	$\bar{X}_i$	262.629	299.425	1022.938	371.851	825.336	
A54-1BB							0.719
	r^2	0.423	0.276	0.251	0.359	0.422	
	$\hat{X}_{max}$	401.865	-486.000m 1/	850.464m	434.222	761.725	
	$\bar{X}_i$	246.918	292.212	976.600	195.679	802.540	
F_1 hybrid							0.701
	r^2	0.238	0.076	0.210	0.121	0.575	
	$\hat{X}_{max}$	224.756	273.194	892.330	249.423m	2942.750	
	$\bar{X}_i$	124.571	213.300	791.462	85.718	610.375	
50-406							0.387
	r^2	0.147	0.065	0.222	0.036	0.302	
	$\hat{X}_{max}$	238.482	52.750	995.167m	82.154m	-27565.505m	
	$\bar{X}_i$	183.218	203.200	905.612	101.365	794.772	
50-406BB							0.608
	r^2	0.154	0.042	0.146	0.078	0.369	
	$\hat{X}_{max}$	336.029	548.958m	839.567m	510.864m	2263125.727	
	$\bar{X}_i$	184.811	201.475	847.525	208.545	703.969	
52-307							0.599
	r^2	0.400	0.257	0.070	0.301	0.483	
	$\hat{X}_{max}$	63.291m	379.812	540.600	393268.649m	15247.000	
	$\bar{X}_i$	118.790	276.900	824.550	52.018	753.692	

1/ m indicates that the estimate is not a maximum.

In table 1, X_6 through X_{10} represent the squares of X_1 through X_5. In table 2 the correlation coefficients for X_6 through X_{10} are not included. They do not affect the biological conclusions, they merely show that the quadratic terms are lending some additional refinement in describing the true response function. In those cases examined, they are less than r^2 for their linear term.

The computational procedures for this type of multiple regression can be obtained from Snedecor (5) or other references on multiple regression. An IBM 1620 computer was used in obtaining these multiple regressions. It is imperative that computing equipment be available for use in this type analysis as simultaneous solutions of several equations in several unknowns are required.

Using plot totals to estimate the partial regressions and multiple correlation coefficients within populations results in estimates of environmental regression of weight per root on the five chemical characters since the genetic variation in the plot totals (or means) is very small compared to the environmental variation. Hence, these regressions may be considered to be estimates of the environmental relationships among characters for each population. The comparison across populations does, however, afford genetic comparisons. For example, it is interesting to note in table 1 that for the populations A54-1 and 50-406 compared with A54-1BB and 50-406BB, eight out of eight of the partial regression coefficients which were significantly greater than zero occurred in the broad base material (A54-1BB and 50-406BB). Furthermore, there are significant differences between the broad base material and the parent material for the partial regression coefficients. For example, for nitrogen (X_1):

$$t = \frac{0.080373 + 0.116938 - 0.017837 - 0.040542}{0.018087^2 + 0.022906^2 + 0.020751^2 + 0.021238^2} = 3.3369$$

$$t = 3.3369 > t_{.01,69df}$$

Without exception, whenever the partial regression coefficient for the linear effect is significant the corresponding partial regression coefficient for the quadratic effect is significant. The genetic explanation of these facts is not immediately apparent.

From a study of the correlations in table 2, there appears to be "heterosis" for the multiple regression coefficient squared in the F_1 as compared to its parents. In other words, the five independent variables being considered account for a greater percentage of the variability of root weight in the F_1 than in either of its parents. This could be due to a homeostatic ability of the F_1 to remain more constant, in its uptake and manufacture of the chemicals measured, over the range of environments

encountered. However, before such conclusions can be definitely drawn, additional biological information is required regarding the biochemistry and physiology of sugar beets.

Another fact, without apparent explanation, is that in table 2 betaine (X_5) has the highest simple correlation coefficient squared for five populations and is not different than that for nitrogen (X_1) in the sixth population (A54-1BB). The simple correlation coefficient squared of nitrogen with weight per root is second highest for three populations and not different than betaine for the highest rank in A54-1BB. Thus, among these five chemical characters when considering each character singly and ignoring all others, it would seem that betaine is the best single predictor of weight per root with total nitrogen being second. There is little difference between sodium, potassium, and glutamic acid in this regard. There would appear to be some genetic differences in the association of the five chemical characters as they affect weight per root. Therefore, the effect of the environment on the relationship between weight per root and chemical characters might be modified by breeding.

Returning to environmental relationships between weight per root and the five chemical characters, in table 2, except for inbred 50-406, between 60 percent and 70 percent (R^2) of the environmental variation in weight per root is accounted for by variation in the five chemical characters. Thus, except for 50-406, only 30 percent to 40 percent of the variation is left unexplained by other independent variables, perhaps other amino acids, phosphorus, etc.

In considering the threshold values of the five chemical characters for maximum weight per root in table 2, it is apparent from examining equation [2] and from conditions previously stated that from the multiple regression analysis, the regression coefficient of X_1, X_2, X_3, X_4, or X_5 must be positive and that of its square, X_6, X_7, X_8, X_9, or X_{10}, must be negative. These conditions are necessary in order that $\hat{X}_i$ be a valid estimate of the threshold point of any chemical character. The sign of these regression coefficients is dependent upon the distribution of the data in which it occurs. Thus, if the data range of a particular chemical character could be extended it might change the signs of the regression coefficients and in so doing allow a more satisfactory fit to the regression model used, although this cannot be presupposed. Those threshold estimates which cannot be considered valid are suffixed in the tables by the letter m. Hence, 11 of the 30 threshold estimates in table 2 are not valid estimates of the point on X_i at which root weight should theoretically reach a maximum. The other 19 threshold estimates should be valid. The few unrealistically large estimates result from the fact that within the range of the data studied the point on X_i was never reached at which root weight commenced to be depressed. The means of the plot totals are included in this table to allow relative comparisons to the threshold estimates. The proximity of the mean and the threshold estimate are, however, no criterion

for evaluating the accuracy of the threshold estimate.

The confidence intervals for these estimates can be calculated from equation [3]. It will be noted from table 2 that there are differences between populations in considering a single independent variable. For example, the threshold value for total nitrogen (X_1) varies from 224.756 for the F_1 to 557.406 for A54-1. For nitrogen the data for the entire experiment ranges from about 40 to 960. Within each population the data ranges from about 50 to 435 for the F_1 and from about 70 to 735 for A54-1. Therefore, the populations differ considerably in the point at which more nitrogen in the thin juice starts to depress root weight. It is also noted in considering the threshold value of total nitrogen for the F_1 that it is near the threshold value of its parent 50-406. But in considering sodium (X_2) the threshold value of the F_1 is nearer its parent 52-307. This comparison cannot be carried through the remaining characters as at least one of the populations under each character has an unrealistic threshold value.

In general these threshold values fall within the range of the data for each population and should, therefore, be useful as estimates of the points at which the chemical constituents commence to depress root weight. In those cases where the mathematical model does not approximate the true response function of the chemical character within the plant, the estimate of the threshold value is not valid.

The information in tables 3 and 4 result from application of the regression model given by equation [1] to each of the six populations within treatments.

In table 3 it will be noted that those partial regression coefficients which are significantly different from zero, with one exception, occur in the non-fertilized treatment. An apparent explanation of this lacking, since the range of the data for each X_i was in general shorter in the non-fertilized than in the fertilized treatment.

Table 3 Partial regression coefficients and their standard errors for the six populations using 40 plot totals in regression equation [1].

Population and treatment	Statistic	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
A54-1											
Non-fertilized	partial b	0.016167	-0.004102	-0.031747	0.018289	-0.042152	-0.000023	0.000023	0.000023	-0.000044	0.000031
	s_b	0.040423	0.015430	0.060465	0.011879	0.036783	0.000115	0.000031	0.000031	0.000079	0.000026
Fertilized	partial b	-0.012647	-0.009522	0.040169	0.000911	-0.009259	0.000006	0.000003	-0.000012	0.000001	0.000003
	s_b	0.036892	0.017658	0.043243	0.011005	0.056365	0.000045	0.000019	0.000018	0.000009	0.000033
A54-1BB											
Non-fertilized	partial b	0.019943	0.015115	0.013475	0.090929*	0.031697	0.000046	-0.000024	-0.000013	-0.000355*	-0.000019
	s_b	0.039395	0.016031	0.087121	0.036688	0.031564	0.000073	0.000033	0.000048	0.000123	0.000019
Fertilized	partial b	-0.032843	0.008175	0.067031	0.013436	0.087295	0.000036	-0.000013	-0.000026	-0.000014	-0.000048
	s_b	0.025288	0.015738	0.035637	0.009992	0.069318	0.000027	0.000018	0.000017	0.000012	0.000037
F_1 hybrid											
Non-fertilized	partial b	0.274219	0.000804	-0.029737	0.021705	0.001505	-0.001365	-0.000004	0.000024	0.000756	0.000001
	s_b	0.135978	0.012470	0.074478	0.047117	0.025550	0.000881	0.000032	0.000049	0.000735	0.000031
Fertilized	partial b	-0.026828	0.007520	0.057827	-0.013991	0.143953*	0.000043	-0.000013	-0.000029	0.000013	-0.000080
	s_b	0.074933	0.021208	0.090454	0.019992	0.066091	0.000168	0.000035	0.000054	0.000045	0.000041
50-406											
Non-fertilized	partial b	0.071416	-0.013225	-0.046456	0.000888	0.013234	-0.000298	0.000051	0.000030*	0.000066	-0.000013
	s_b	0.069007	0.013315	0.024081	0.013896	0.017830	0.000288	0.000047	0.000014	0.000077	0.000015
Fertilized	partial b	-0.000474	-0.018714	0.028801	0.003174	-0.016998	-0.000000	0.000020	-0.000017	0.000001	0.000009
	s_b	0.040755	0.017697	0.070064	0.005954	0.020369	0.000082	0.000028	0.000037	0.000015	0.000010
50-406BB											
Non-fertilized	partial b	0.228017*	-0.031782	0.014298	-0.034509	-0.004572	-0.000857*	0.000086	-0.000005	0.000261	0.000001
	s_b	0.088538	0.019738	0.071917	0.024684	0.017877	0.000402	0.000056	0.000045	0.000139	0.000014
Fertilized	partial b	0.049298	-0.003545	-0.026099	-0.011746	0.081213	-0.000112	-0.000004	0.000019	0.000018	-0.000047
	s_b	0.048301	0.011454	0.042474	0.010334	0.042895	0.000082	0.000019	0.000024	0.000012	0.000024
52-307											
Non-fertilized	partial b	-0.095068*	0.023960*	0.028509	0.197918*	-0.001804	0.000606*	-0.000037*	-0.000016	-0.003058*	0.000003
	s_b	0.048052	0.008080	0.044978	0.068702	0.012518	0.000267	0.000017	0.000027	0.001297	0.000010
Fertilized	partial b	0.007422	-0.002683	-0.002001	-0.051204	0.017664	-0.000000	0.000002	0.000001	0.000188	-0.000007
	s_b	0.062522	0.013289	0.078905	0.030282	0.033287	0.000211	0.000016	0.000050	0.000157	0.000019

* Denotes that the partial regression coefficient is significantly greater than zero at the five percent level.

Table 4 is a comparison within treatments and within populations of the multiple correlation coefficients squared, the simple correlation coefficients squared, threshold estimates of X_i, and means of the plot totals. Under non-fertilized conditions, between 49 percent and 72 percent (R^2) of the environmental variation in root weight for the six populations is accounted for by variation in the five chemical characters. Under fertilized conditions only 26 to 44 percent of the environmental variation is accounted for by variation in the five independent variables. For every population under the fertilized treatment the multiple correlation coefficient (R^2) is lower than in table 2 where the treatments were ignored. However, under the non-fertilized treatment R^2 is greater in certain populations than it was in table 2, namely A54-1, 50-406, and 52-307. It is equal in the F_1 and less in A54-1BB and 50-406BB. Hence, in general, under the conditions of this experiment, when only non-fertilized treatments are considered these five chemical characters account for a greater percentage of the environmental variability in root weight than when considered across treatments. In other words, the greatest amount of variability in root weight would seem to be accounted for by analysing only within the non-fertilized treatment.

The threshold values derived using equation [2] are listed in table 4. In most cases where the regression model resulted in realistic estimates of the threshold values, it is noted that the estimate is higher under the fertilized than under the non-fertilized treatment. Also, in most cases where there is a realistic estimate of the point at which root weight is a maximum, the threshold estimate in table 2 is found to be between the two corresponding estimates in table 4. This logically suggests that those estimates in table 2 are probably more accurate than those of table 4, since there are twice as many observations on which the regression is calculated and the range of the data across treatments is greater than the range of the data within either treatment.

Table 4 Simple correlation coefficients squared, multiple correlation coefficients squared, estimated threshold values for maximum root weight, and means of plot totals for five chemical characters using regression equation [1].

Population and treatment	Statistic	Character (among 40 plots) X_1	X_2	X_3	X_4	X_5	R^2
A54-1							
Non-fertilized							0.700
	r^2	0.228	0.247	0.437	0.172	0.360	
	$\hat{X}_{max}$	350.948	88.306m 1/	700.604m	209.109	678.730m	
	$\bar{X}_1$	150.800	215.875	980.875	102.765	718.170	
Fertilized							0.261
	r^2	0.025	0.003	0.131	0.044	0.006	
	$\hat{X}_{max}$	1007.308m	1513.658m	1722.295	-330.280m	1447.852m	
	$\bar{X}_1$	374.458	382.975	1065.000	640.938	932.502	
A54-1BB							
Non-fertilized							0.570
	r^2	0.313	0.278	0.127	0.143	0.096	
	$\hat{X}_{max}$	-215.996m	311.739	532.116	128.231	827.287	
	$\bar{X}_1$	135.502	196.975	915.450	60.885	684.192	
Fertilized							0.333
	r^2	0.005	0.002	0.079	0.019	0.003	
	$\hat{X}_{max}$	460.446m	309.945	1297.506	470.121	900.565	
	$\bar{X}_1$	358.332	387.450	1037.750	330.472	920.888	
F_1 hybrid							
Non-fertilized							0.718
	r^2	0.253	0.227	0.365	0.224	0.277	
	$\hat{X}_{max}$	100.422	92.690	610.671m	-14.364m	-551.679m	
	$\bar{X}_1$	78.530	158.975	767.975	27.785	410.330	
Fertilized							0.445
	r^2	0.019	0.100	0.058	0.059	0.072	
	$\hat{X}_{max}$	309.338m	294.950	1009.118	526.867m	898.789	
	$\bar{X}_1$	170.612	267.625	814.950	143.650	810.420	
50-406							
Non-fertilized							0.488
	r^2	0.022	0.056	0.242	0.001	0.073	
	$\hat{X}_{max}$	119.679	129.201m	763.611m	-6.706m	492.843	
	$\bar{X}_1$	116.500	138.875	830.275	64.048	587.445	
Fertilized							0.276
	r^2	0.018	0.075	0.026	0.002	0.002	
	$\hat{X}_{max}$	-953.095m	466.917m	849.263	-1657.859m	996.292m	
	$\bar{X}_1$	249.935	267.525	980.950	138.682	1002.100	
50-406BB							
Non-fertilized							0.491
	r^2	0.186	0.142	0.294	0.061	0.087	
	$\hat{X}_{max}$	132.971	185.335m	1319.793	66.234m	3120.606m	
	$\bar{X}_1$	100.945	150.950	794.725	51.065	558.945	
Fertilized							0.408
	r^2	0.123	0.215	0.014	0.120	0.004	
	$\hat{X}_{max}$	220.303	-458.277m	685.089m	329.512m	859.784	
	$\bar{X}_1$	268.678	252.000	900.325	366.025	848.992	
52-307							
Non-fertilized							0.714
	r^2	0.401	0.499	0.006	0.248	0.196	
	$\hat{X}_{max}$	78.496m	325.998	894.558	32.357	354.260m	
	$\bar{X}_1$	88.555	206.775	854.050	23.878	638.090	
Fertilized							0.263
	r^2	0.045	0.000	0.009	0.014	0.039	
	$\hat{X}_{max}$	43250.350	732.343m	1722.678m	135.846m	1264.520	
	$\bar{X}_1$	149.025	347.025	795.050	80.158	869.295	

1/ m indicates that the estimate is not a maximum.

In the non-fertilized treatment there are only 15 threshold estimates, (table 4), which could be maximums and which, therefore, are valid. In the fertilized treatment there are only 13 which could be maximums. Hence, this would indicate a better fit of the data to the regression model when treatments are ignored. This is true in spite of the fact that slightly more variation in root weight is accounted for by the X_i within the non-fertilized treatment than across treatments.

The exponential regression model given in equation [5] was applied to the same data for weight per root with the five chemical characters for each of the six population over treatments. This information appears in tables 5 and 6.

After examining some of the actual distributions of plot totals for root weight with the independent variables (X_i), it would appear that this exponential regression model may not be a substantially better approximation of the actual response function than was the quadratic regression model. However, it would appear to be a better approximation when considering percentage sucrose and percentage apparent purity with the five chemical characters. This will not be examined in this portion of the study.

In table 5 the coefficient of the log term for total nitrogen (X_1 in the table) is significantly different than zero in three populations. The only other significant coefficients occur in the inbred 52-307. This dearth of significance among these partial regression coefficients is not, however, an indication of a lack of correspondence of the actual response function and the mathematical model.

From table 6 it is possible to get some indication of the merit of the exponential regression model in describing the true response function of the X_i on root weight. With the exception of the inbred 50-406, between 65 and 75 percent (R^2) of the environmental variation in root weight is accounted for by the variation in the five chemical characters. Thus, only 25 to 35 percent of the variation is left unexplained by other independent variables which affect root weight. In 50-406 only 40 percent of the variation is accounted for by the variation in the X_i. These multiple correlation coefficients correspond quite closely to those in table 2 but are in general higher. This would indicate that the exponential regression equation [5] is a better approximation to the true response function of root weight to the five chemical characters.

Table 5 Partial regression coefficients and their standard errors for the six populations using 80 plot totals in regression equation [5].

Population	Statistic	Character									
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
A54-1	partial b	0.322443	0.184694	0.856348	0.032611	-0.033840	-0.000901	-0.000645	-0.000223	0.000069	-0.000108
	s_b	0.203666	0.116362	1.409965	0.035285	1.077696	0.000776	0.000388	0.001334	0.000162	0.001408
A54-1BB	partial b	0.511583*	0.134874	-1.142621	0.046097	0.824110	-0.000745	-0.000638	0.001196	-0.000060	-0.000991
	s_b	0.234094	0.127475	1.605304	0.057193	1.052141	0.000879	0.000537	0.001635	0.000258	0.001298
F_1 hybrid	partial b	0.647845*	0.075079	1.221890	0.052676	0.028313	-0.002879	-0.000574	-0.000840	-0.000439	0.000137
	s_b	0.222778	0.088504	2.136820	0.044125	0.311239	0.001593	0.000473	0.002647	0.000545	0.000642
50-406	partial b	0.883512	0.043126	-1.324120	-0.024401	0.069364	-0.003566	-0.000776	0.001434	0.000721	0.000009
	s_b	0.465833	0.154402	2.559297	0.074081	0.617252	0.002588	0.000952	0.002773	0.000738	0.000758
50-406BB	partial b	0.740537*	-0.023138	-0.168451	-0.028734	0.494409	-0.001556	-0.000388	0.000273	-0.000094	-0.000765
	s_b	0.240416	0.105972	1.702645	0.054918	0.558659	0.002006	0.000619	0.001986	0.000548	0.000838
52-307	partial b	-0.978307	0.965680*	3.730739	0.349924*	1.456830	0.011392	-0.002926*	-0.005424	-0.006294*	-0.001497
	s_b	0.668954	0.212673	4.662617	0.113137	1.359779	0.006137	0.000867	0.005660	0.003002	0.002018

* Denotes that the partial regression coefficient is significantly greater than zero at the five percent level.

Table 6 Simple correlation coefficients squared, multiple correlation coefficients squared, estimated threshold values for maximum root weight, and means of plot totals for five chemical characters, using regression equation [5].

Population	Statistic	Character (among 80 plots)					
		X_1	X_2	X_3	X_4	X_5	R^2
A54-1							0.653
	r^2	0.505	0.394	0.318	0.493	0.409	
	$\hat{X}_{max}$	357.963	286.314	3832.118	-471.784m 1/	-313.159m	
	$\bar{X}_i$	262.629	299.425	1022.938	371.851	825.336	
A54-1BB							0.691
	r^2	0.609	0.378	0.250	0.507	0.463	
	$\hat{X}_{max}$	686.881	211.416	955.767m	774.417	831.326	
	$\bar{X}_i$	246.918	292.212	976.600	195.679	802.540	
F_1 hybrid							0.746
	r^2	0.481	0.179	0.241	0.485	0.575	
	$\hat{X}_{max}$	225.055	130.744	1454.164	120.045	-206.825m	
	$\bar{X}_i$	124.571	213.300	791.462	85.718	610.375	
50-406							0.404
	r^2	0.272	0.151	0.257	0.126	0.341	
	$\hat{X}_{max}$	247.733	55.539	923.606m	33.856m	-7528.927m	
	$\bar{X}_i$	183.218	203.200	905.612	101.365	794.772	
50-406BB							0.647
	r^2	0.410	0.113	0.182	0.340	0.423	
	$\hat{X}_{max}$	475.785	-59.628m	618.164m	-305.108m	646.186	
	$\bar{X}_i$	184.811	201.475	847.525	208.545	703.969	
52-307							0.664
	r^2	0.432	0.391	0.061	0.392	0.416	
	$\hat{X}_{max}$	85.876m	330.035	687.867	55.599	972.991	
	$\bar{X}_i$	118.790	276.900	824.550	52.018	753.692	

1/ m indicates that the estimate is not a maximum.

Upon examining the simple correlation coefficients of each character with root weight in table 6, it is first noticed that betaine (X_5) is not consistently the best or one of the best single predictors of root weight as it was in table 2. Betaine has the highest simple correlation coefficient in three of the populations, while total nitrogen has the highest simple correlation coefficient for the remaining three populations.

From a genetic point of view there appears to be in table 6, as in table 2, "heterosis" for the multiple regression coefficient in the F_1 as compared to its parents.

In considering the estimated threshold values for the X_i in table 6, it appears that the exponential regression equation [5] generates slightly better estimates for the individual independent variables. As in table 2, there are 19 threshold estimates which are valid. There are not, however, any unrealistically large estimates as there were in table 2.

Discussion

The partial regression coefficients of table 1, 3, and 5, in the majority of the cases, cannot be shown to be different than zero. Hence, the strength of the relationships of the individual X_i with root weight is not great when the remaining X_i are held statistically constant. These relationships could probably be enhanced by a greater range in the data and greater numbers. However, this experiment is more extensive than most experiments to which these methods might be applied. This lack of significance is not a good indicator of the degree of correspondence between the regression models and the distribution of the data.

After examination of the multiple regression coefficients and the threshold estimates it appears that the two polynomial multiple regression models used are both fair approximations to the true form of the response curve when applied within populations and across treatments. This is particularly true in the populations A54-1, A54-1BB, F_1, and 52-307. Considering the multitude of factors which affect root weight, it is encouraging to note that as much as 75 percent of the total environmental variability in root weight is accounted for by the variability in the chemical characters. By working within each population, the genetic affect of the differences between populations has been eliminated. This should cause the proposed models to correspond more closely to the actual distribution of the data, since as was pointed out earlier the ranges of the data vary between populations, sometimes even failing to overlap. It would appear that the multiple correlation coefficients squared, considered together with the threshold estimates should be used to evaluate the fit of the model to the actual data. However, a good fit to the mathematical model does not assure that the estimate of the threshold value for every

independent variable will be realistic. This would depend upon the relation of the individual chemical character to root weight while all other chemical characters are statistically held constant.

It would seem that the best fit to the quadratic regression model, equation [1], occurs under the non-fertilized treatment. This is probably due to the fact that the fertilizer treatment has increased, in general, the variability of the plot totals of the individual chemical characters. These variances are not shown, but except for betaine and potassium the variances are all higher under the fertilized treatment. For betaine the variance of the plot totals is reduced under the fertilized treatment except in population A54-1. For potassium this variance is reduced under the fertilized treatment only in the inbred populations.

Despite the fact that within the non-fertilized treatment a slightly better fit to equation [1] was achieved for most populations than across treatments, it is not likely that this would hold true in all cases.

The exponential regression model, equation [5], has not been applied within treatments, but considering its superiority as applied across treatments it seems likely that this model gives the best fit, considering all populations. Therefore, the threshold estimates using equation [5] are likely to be the most accurate.

It appears that the threshold value for any character is not reached at the same point in all populations. In other words, if the point at which a particular chemical character commences to depress yield is estimated in one population it cannot be used as an estimate in all populations. This would indicate that it should be possible to breed for a lower or higher level of a chemical character without decreasing root weight. This has been demonstrated by Payne, Powers, and Maag (2) where they provide evidence that it is possible to breed sugar beets for a different total nitrogen level in the thin juice without necessarily affecting the yield.

Although the formulas for calculating confidence limits on the threshold estimates have been developed, the actual limits have not been calculated. These calculations will be made using computing equipment and will be included in the overall study when percentage sucrose and percentage apparent purity are also considered in relation to the independent variables of this study.

This idea of establishing threshold values for particular characters in relation to root yield is not new. In the past experimenters have attempted to estimate the point at which a particular character commenced to depress root yield, by examining the means and frequency distributions of a dependent and independent character. It is impossible, however, to consider simultaneously in this manner the joint effect of other variables.

This multiple regression type analysis is an attempt to refine the estimation of these threshold values. Methods of calculus are used in establishing a precise value for the threshold point. Of course the accuracy of the estimate is a function of the degree of correspondence of the approximating mathematical model to the true response function in the plant. If the mathematical model accounts for all or most of the variability of the dependent variable then the estimates of threshold values should be quite highly accurate. If, on the other hand, the model is "a poor fit", accounting for only a small percentage of the total variability, the estimates of the threshold values would be, in general, highly inaccurate. It must be remembered at the same time that certain variables under consideration may have no threshold value within the range of the dependent variable. This would not affect the fit of the model but may cause the experimenter to be unduly dubious of the entire estimation procedure. Another factor which may affect this method is a relationship between some of the independent variables (X_i). In this study such relationships undoubtedly exist. For instance, there is probably a relation of total nitrogen with glutamic acid and betaine, since they are both nitrogenous compounds. Also certain characters might conceivably be quite closely related to the dependent yield character, yet actually unimportant in its determination. It is not clear at this point how such interrelationships may affect the methods of this study.

No general conclusions can be developed from this preliminary study regarding the methods or the threshold estimates for the chemical characters in the different populations. However, if the mathematical model used provides a satisfactory fit to the data it should at the same time yield reasonably accurate threshold estimates. Such estimates may be diectly useful as breeding tools. They could be useful in evaluating varieties or breeding material under different environments as regards fertility, climate, soil type, etc., since it has been demonstrated by Powers, Schmehl, Federer, and Payne (4), that it may be possible to breed varieties which will maintain high root weight, percentage sucrose, and percentage apparent purity under higher nitrogen levels than are commonly recommended.

The threshold estimates for the characters considered in this study, even though valid, may not all be directly useful. However, the methods may be useful when applied to other characters and other populations in evaluating the relationships between yield characters and independent variables of interest.

Summary

1. The environmental interrelationships of weight per root with five chemical characters in the thin juice are studied in three segregating and three non-segregating populations.

2. Two mathematical models are considered in an attempt to describe the

response function of weight per root on the five chemical characters. The two polynomial multiple regression models are compared through the use of regression coefficients, correlation coefficients, and threshold estimates for the chemical characters.

3. Both polynomial regression models provide fair approximations to the true form of the response curve when applied across fertility treatments, accounting for as much as 75 percent of the total environmental variability in root weight.

4. Considering all the statistics developed, the exponential multiple regression model provides a slightly better fit to the true environmental relation between root weight and the five chemical characters than does the quadratic multiple regression model.

5. Certain of the threshold estimates in this study are not maximums and, thus, are not valid estimates of the threshold points at which the individual chemical characters commence to depress root weight.

6. Threshold estimates developed in this manner may be useful as breeding tools in evaluating breeding material under different environments and in predicting which characters should be emphasized when selecting.

Literature Cited

(1) Kenney, J. F., and Keeping, E. S. 1951. Mathematics of Statistics, Part 2, D. Van Nostrand Co., New York.

(2) Payne, Merle G., Powers, LeRoy, and Maag, Grace W. 1959. Population genetic studies on the total nitrogen in sugar beets (Beta vulgaris L.). Jour. Amer. Soc. Sugar Tech. X(7):631-646.

(3) Powers, LeRoy, Robertson, D. W., Whitney, R. S., and Schmehl, W. R. 1958. Population genetic studies with sugar beets (Beta vulgaris L.) at different levels of soil fertility. Jour. Amer. Soc. Sugar Beet Tech. IX(8):637-676.

(4) Powers, LeRoy, Schmehl, W. R., Federer, W. T., and Payne, Merle G. Chemical genetic studies involving thirteen characters in sugar beets. (In process of publication).

(5) Snedecor, George W. 1956. Statistical Methods, Iowa State College Press, Ames, Iowa.

DEVELOPMENT OF TETRAPLOID LINES AND COMPARISON OF DIPLOID AND TETRAPLOID EQUIVALENTS

Investigations at this station and investigations by others indicate that there is an interaction of genotype and ploidy level as regards weight per root and percentage sucrose in sugar beets. Not only do particular genotypes act differently at ploidy levels above the diploid but different genotypes do not react in a similar manner when in the triploid or tetraploid condition. Thus it would seem that any true beneficial effect of triploidy could be exploited most effectively by using those genotypes which have a favorable interaction between genotype and ploidy level. This can be done only by examining an increased number of genotypes.

New tetraploid inbred lines are being developed at this station with particular interest on those inbred lines which have cytoplasmic male-sterile equivalents and those inbred lines which have shown superior specific combining ability at the diploid level for weight of root and percentage sucrose or both.

Tetraploids have been made of the following inbred lines since submitting the last report.

52-305, cytoplasmic male sterile
52-305, male fertile
52-414
54-346
54-403
54-565

Comparisons were made in 1961 between diploids and their tetraploid equivalents. The data are tabulated in table 1. The characters studied are weight per root and percentage sucrose. The experimental design is a modified randomized complete block with three replications, the modification being paired plantings of the diploid and tetraploid of each population. This modification facilitated visual comparisons during the growing season. Single-row plots were used with forty-four inch spacings between rows.

The stand was adequate in all plots for a competitive 10-root sample except for 50-620(4n). Hence, for this inbred line only percentage sucrose data are reported, the lack of within row competition having much less effect on sucrose percentage than on root weight.

In table 1 the entries A60-6 and A60-5 are diploid and tetraploid equivalents but are varieties and therefore heterozygous. The entries A60-4 and A56-3 are also heterozygous and are included only as comparative checks. They are not equivalents. All other populations are inbreds and their corresponding tetraploids.

Table 1 Means for weight per root in kg. and percentage sucrose in tetraploid and diploid equivalents and others; 1961 data.

Population	Generation	Weight per root in kg.	Percentage sucrose
52-307(2n)		0.823	12.20
52-307(4n)	C_5	0.667	12.50
50-406(2n)		0.622	12.63
50-406(4n)	C_4	0.662	12.90
50-620(2n)			5.50
50-620(4n)	C_3		6.57
54-480(2n)		1.015	9.73
54-480(4n)	C_3	0.615	10.73
52-430(2n)		0.650	11.90
52-430-3(4n)	C_5	0.597	11.73
52-430(2n)		0.579	12.30
52-430-5(4n)	C_5	0.527	12.73
A60-6, (Polish monogerm)(2n)		1.027	11.03
A60-5, (Polish monogerm)(4n)	unknown	1.060	11.00
A60-4, (Janasz)(4n)	unknown	0.945	13.37
A56-3, (GW359-52R)(2n)		1.053	13.00

Table 2 Analysis of variance for weight per root in kg. of diploid and tetraploid equivalents; 1961 data.

Source of variation	Mean square	F value	F at 5%	F at 1%
Ploidy levels	0.086436	11.651 b 1/	18.51	98.49
Populations	0.187106	16.666**a	3.33	5.64
Replications	0.000208	c		
Levels X Pops.	0.040422	4.914* c	3.33	5.64
Pops. X Reps. (a)	0.011227	1.365 c	2.97	4.85
Levels X Reps. (b)	0.007419	c		
L X P X R (c)	0.008226			

1/ The small letters after the F values indicate the error mean square used in calculating F.

Table 3 Analysis of variance for percentage sucrose of diploid and tetraploid equivalents; 1961 data.

Source of variation	Mean square	F value	F at 5%	F at 1%
Ploidy levels	1.7600	35.200* b 1/	18.51	98.49
Populations	33.1567	82.892**a	3.00	4.82
Replications	1.3400	2.366 c	3.98	7.20
Levels X Pops.	0.3350	c		
Pops. X Reps. (a)	0.4000	c		
Levels X Reps. (b)	0.0500	c		
L X P X R (c)	0.5664			

1/ The small letters after the F values indicate the error mean square used in calculating F.

It will be noted from table 1 that for root weight the tetraploids are not consistently better nor consistently poorer than the diploids. The effect of the ploidy level seems to be dependent on the population. This is further substantiated by the data in table 2, where it will be noted that the population by ploidy level interaction is significant, while the ploidy levels are not different. In other words, the different populations react differently when changed to a tetraploid condition. This is consistent with data from previous years. In the analysis of tables 2 and 3 only those populations were included which had diploid and tetraploid equivalents, the comparative checks being excluded from the analysis.

It is apparent from table 1 that the tetraploid populations are in general higher in percentage sucrose than their diploid counterparts. The analysis of table 3 shows that there is a significant difference between ploidy levels, but that the population by ploidy level interaction is not significant. Thus all populations seem to be reacting in a somewhat similar manner in the tetraploid condition.

There are highly significant differences between populations for both characters, as shown by tables 2 and 3, this is evident from an examination of the means in table 1.

Considering the limitations of only three replications these results should be taken only as indicative. Expansion of these polyploid studies is contemplated to allow comparisons in the diploid, triploid, and tetraploid conditions. Further, it is planned to compare specific F_1 hybrid genotypes at the three ploidy levels. From these comparisons should come fundamental information about the true effect of polyploidy and its interaction with the genotype.

PART VII

POLYPLOIDY IN RELATION TO ROOT YIELD, SUCROSE PERCENTAGE, AND DISEASE RESISTANCE

- - -

INTERSPECIFIC HYBRIDIZATION and STUDIES ON TETRAPLOIDY

Foundation Project 11

Helen Savitsky V. F. Savitsky

Geneticists, Crops Research Division, ARS, USDA, Salinas, Calif. Formerly Collaborators, employed by the Beet Sugar Development Foundation.

POLYPLOIDY IN SUGAR BEETS

STUDY OF INHERITANCE OF CURLY TOP RESISTANCE. 1. ANALYSIS OF MEANS IN DIPLOID AND TETRAPLOID HYBRIDS BETWEEN MONOGERM AND MULTIGERM BEETS.

By V. F. Savitsky

Previous experiments indicated that several tetraploid populations exhibited higher resistance to curly top than their immediate diploid ancestors. This was true for the varieties US 35/2, US 401, US 104, and some others. It was also shown that the rise in grade of resistance was not similar in all tetraploids when compared to the original diploids.

To study the inheritance for curly top resistance in diploids and tetraploids, a common technique for study of quantitative characters was applied; i.e., simultaneous study of parental strains, together with F_1, F_2 and backcross hybrids to both recurrent parents.

Materials and Methods

Scheme of experiment for diploid strains. Diploid self-fertile SLC 91 mm, low in curly top resistance, was crossed to the highly curly top resistant diploid multigerm variety US 35/2. F_1 multigerm plants were selfed for obtaining F_2 seed and simultaneously crossed to obtain b_1 and b_2 seed, with both parents (male-sterile monogerm equivalent of SLC 91mm and multigerm self-sterile US 35/2).

Scheme of experiment for tetraploid strains. Analogous crossins and selfings were conducted with the tetraploid monogerm strain SLC 91 and the tetraploid multigerm variety US 35/2.

Experimental design. Seeds of the diploid and tetraploid parental strains (US 35/2 and SLC 91), and the diploid and tetraploid F_1, F_2, b_1 and b_2 hybrids, were planted in 4 replications in randomized complete block design at Jerome, Idaho. Curly top exposure was very severe at Jerome in 1961. The susceptible variety US 333 was completely destroyed by curly top and in the diploid variety US 35/2 all, or almost all, plants were injured.

Readings of the grade of curly top resistance were made for individual plants, using a 10-unit scale (grade 1 plants without visible injury, grade 10 plants killed by curly top). Not less than 30 plants were recorded in each replication. For each replication the average grade of curly top resistance was calculated and the analysis of variances is presented. (Table 1).

Analysis of variance showed that variations between blocks were small, but significant. The main factors of variability in resistance to curly top were "the level of ploidy" and "varieties".

Variance of "ploidy level" equalled 39.9786. This magnitude exceeded by almost 3 times (2.967 times) the magnitude of variance for "varieties" which equalled 13.4623.

In such a way, autotetraploidy represents a factor which may significantly change the grade of curly top resistance in beets.

Interaction between "ploidy level" and "varieties" was established. The magnitude of this interaction is comparatively low ($\sigma^2 = 1.8674$), but it is highly significant. In other words, different beet populations do not respond identically in resistance to curly top when their ploidy level is changed.

Table 1.--Analysis of variance of curly top resistance in diploid and tetraploid hybrids between mono-and multigerm beets. Plot data, Jerome 1961.

Variation	Degrees of freedom	Sum of squares	Variance	Variance ratio	F P = 0.05	F P = 0.01
Total	47	118.9002				
Blocks	3	0.5392	0.1797	3.4219	2.90	4.46
Populations or completed analysis of "populations"	11	116.6268	10.6024	201.8928	2.10	2.86
Ploidy level	1	39.9786	39.9786	761.2796	4.15	7.50
Varieties	5	67.3114	13.4623	256.3515	2.51	3.66
Interaction: Level-variety	5	9.3368	1.8674	35.5594	2.51	3.66
Error	33	1.7342	0.05252			

Experimental results.

Inheritance of curly top resistance in diploid hybrids.

The diploid multigerm variety US 35/2, usually high in curly top resistance, was severely injured by curly top in 1961 (its grade of curly top resistance was 5.3779). Under heavy curly top exposure, the diploid inbred SLC 91 was almost completely destroyed (grade of resistance equalled 7.8322), as well as a low in resistance variety US 333.

Difference in resistance between the diploid parental strain SLC 91 mm and US 35/2 equalled 2.41 points. This difference was highly significant.

The diploid F_1 hybrid between the above-mentioned strains showed a grade of curly top resistance of 5.83. This observed grade of resistance in the F_1 hybrid exceeded significantly the mean curly top resistance of both parental strains $\frac{(P_1 + P_2)}{2}$ (table 3). Thus, resistance to curly top proved to be, to a great extent, a dominant character, even under a severe curly top exposure.

Effect of dominance in F_1 diploid hybrids, estimated according to the formula $\frac{(F_1 - P_1) + (F_1 - P_2)}{P_2 - P_1}$, equalled 0.6289. Since, according to this formula, the complete absence of dominance equals 0, the observed value of the effect of dominance must be considered to be high. Partial dominance of genes responsible for curly top resistance may be the reason for the success in breeding for resistance in the open pollinated self-sterile varieties.

Accumulation through breeding of dominant polygenes which favor resistance to curly top allows the use of this character in breeding for resistance based on the heterosis effect. Usually, propagation of hybrids decreases the value of population for a number of characters. By inbreeding, F_2 hybrids derived from selfed F_1 usually reduce the resistance to curly top in comparison with F_1 hybrids.

Actually, resistance to curly top in F_2 hybrids equalling 6.3034, was lower than the resistance in F_1 hybrids which was 5.8372. The difference of 0.4692 between the values of resistance in F_1 and F_2 hybrids is significant, since the msd is 0.3896.

Genetic effect of inbreeding results in the fixation of characters. For non-additive types of genes (for instance dominant genes) such fixation in the F_2 causes the appearance of a new level of expression of resistance to curly top different from the level in F_1. Probably, the reduction in curly top resistance by inbreeding is caused also by the fact that the inheritance of curly top resistance is partially based on non-allelic interaction of genes responsible for curly top resistance (epistasis, complementary action of dominant non-allelic genes, etc.). Our data on comparative study of curly top resistance in F_1, F_2, and backcross hybrids, confirm the non-allelic action of these genes.

Resistance to curly top in b_1 (MS.SLC 91mm x F_1) equalled 7.6667; curly top resistance in b_2 (F_1 x US 35/2) was 5.7295. The difference in resistance between these 2 hybrids is 1.9372 which is highly significant (table 2).

At the non-allelic interaction between genes responsible for curly top resistance, the observed grade of resistance in the F_2 does not equal the theoretical resistance in the F_2, calculated according to the formula $F_2 = \frac{b_1 + b_2}{2}$.

Table 2.--Curly top grades of diploid and tetraploid parents, F_1, F_2, b_1 and b_2 hybrids of sugar beets.

Populations	Average curly top grade		Difference between diploids and tetraploids
	diploids	tetraploids	
P_1: SLC 91 monogerm	7.8322	7.7767	-0.0555
P_2: US 35/2 multigerm	5.3779	3.2643	-2.1136**
Difference: $P_2 - P_1$	-2.4543**	-4.5124**	
F_1	5.8342	4.3815	-1.4527**
F_2	6.3034	4.0689	-2.2345**
Difference: $F_2 - F_1$	+0.4692*	-0.3126	
b_1 backcross	7.6667	4.8919	-2.7748**
b_2 backcross	5.7295	3.4092	-2.3203**
Difference: $b_2 - b_1$	1.9372**	1.4827**	
msd	0.3896	0.3896	0.3896
lsd	0.6462	0.6462	0.6462

*Significant at 5-percent point.

**Significant at 1-percent point.

Really, the observed value in F_2 resistance equalled 6.3034 in this experiment and differed significantly from the grade of resistance calculated by the above-mentioned formula, according to which the resistance in F_2 should be 6.6981 (table 2).

Such a discrepancy between an observed and theoretically estimated magnitude of resistance, based on evaluation of resistance in both back-cross hybrids, is caused by a drop in resistance in the backcross hybrids derived from crosses of F_1 to the parent low in resistance. Resistance in such backcross hybrids did not differ from the grade of resistance in the low resistant parent (7.8322). In our experiment the grade of resistance of the backcross hybrids was 7.6667. By the interaction of only additive genes, resistance to curly top, calculated according to the formula $\frac{P_2 + F_1}{2} = F_2$, should equal 6.8332. In the given case, difference between observed resistance and resistance calculated according to the formula $\frac{P_1 + F_1}{2}$, equalled 0.8335 and was significant.

Thus, the resistance to curly top is controlled by a complicated mechanism; this mechanism includes not only the genes of additive type but also genes with dominant effect and genes with non-allelic reaction. In spite of a comparatively short time of selection for curly top resistance, the recombination phenomenon appeared to be complicated in diploid beets.

Potential maximum curly top resistance may be obtained when in addition to a common selection of resistant strains (fixation of mainly additive-type genes), the method of selection for combining ability in curly top resistance is employed.

Optimum phenotypic expression of curly top resistance as well as optimum manifestation of many other traits, in beets, is connected with maximum expression of heterosis effect in this character.

Inheritance of curly top resistance in tetraploid hybrids.

According to the analysis of variance, the main factor of variability in curly top resistance was the level of ploidy. Mean resistance for 6 diploid populations equalled 6.4573, whereas mean resistance for 6 tetraploid populations was 4.6321. Although tetraploids had a better mean value, the tetraploid strains differed greatly in their grade of resistance.

Almost all tetraploid populations, US 35/2, F_1, F_2, and backcross hybrids, were considerably less injured than the corresponding diploids; this difference was significant. For instance, tetraploid strain US 35/2 exceeded in resistance tetraploid SLC 91 to a greater degree than was observed for the corresponding diploids (table 2). Tetraploid F_1 hybrid between these 2 strains also showed higher resistance than the corresponding F_1 diploid hybrid. Only the inbred line SLC 91 did not show significant difference at diploid and tetraploid levels. Difference in curly top resistance between diploid and tetraploid inbred lines SLC 91 was observed under a mild curly top infection only. Under a severe curly top exposure both strains were severely damaged.

The observed curly top resistance in F_1 tetraploid hybrids was also significantly higher than their theoretical resistance calculated on the basis of the mean resistance of both parents. (Table 4).

Table 3.--Experimental and theoretical means and standard errors of curly top resistance in diploid sugar beet hybrids between monogerm SLC 91 and multigerm US 35/2.

Populations	Means of curly top grades: Experimental	Calculated	Difference Exp. - calculated
P_1 SLC 91 monogerm	7.8322	—	—
P_2 US 35/2 multigerm	5.3779	—	—
F_1	5.8342	$\frac{P_1 + P_2}{2} = 6.6051$	$-0.7709^{**} \pm 0.1400$
F_2	6.3034	$\frac{P_1 + 2F_1 + P_2}{4} = 6.2196$	0.0838 ± 0.0810
F_2	6.3034	$\frac{B_1 + B_2}{2} = 6.6981$	$-0.3947^{*} \pm 0.0810$
B_1	7.6667	$\frac{P_1 + F_1}{2} = 6.8332$	$0.8335^{**} \pm 0.0810$
B_2	5.7295	$\frac{P_2 + F_1}{2} = 5.6061$	0.1234 ± 0.0810
msd			0.3896
lsd			0.6462

*Significant at 5-percent point.

**Significant at 1-percent point.

Table 4.--Experimental and calculated means and standard errors of curly top resistance in tetraploid sugar beet hybrids between monogerm SLC 91 and multigerm US 35/2.

Populations	Means of curly top grades: Experimental	Calculated	Difference Exp. - calculated	
P_1 SLC 91 monogerm	7.7767	—	—	
P_1 US 35/2 multigerm	3.2643	—	—	
F_1	4.3815	$\frac{P_1 + P_2}{2} = 5.5205$	1.1390**	0.1400
F_2	4.0689	$\frac{P_1 + 2F_1 + P_2}{4} = 4.9510$	0.8821**	0.0810
F_2	4.0689	$\frac{B_1 + B_2}{2} = 4.1506$	0.0817	0.0810
B_1	4.8919	$\frac{P_1 + F_1}{2} = 6.0791$	1.1872**	0.0810
B_2	3.4092	$\frac{P_2 + F_1}{2} = 3.8229$	0.4137*	0.0810
msd			0.3896	
lsd			0.6462	

*Significant at 5-percent point.

**Significant at 1-percent point.

Thus, the phenomenon of dominance of curly top resistance, observed in diploid F_1 hybrids, is established also for tetraploid F_1 hybrids.

A diploid F_2 hybrid, obtained from selfed F_1 hybrid, was significantly lower in curly top resistance (table 2 and 3) as compared to the F_1 generation. At the same time, the grade of resistance in a tetraploid F_2 hybrid, also obtained from selfed F_1, did not differ significantly from the resistance in F_1 tetraploid hybrid (table 2 and 4). Tetraploid heredity delays the phenomenon of recombination and this provides for the same effect of dominance in F_2 hybrids, as in F_1 hybrids.

The gene pool, possessed by the diploid parents, when turned to tetraploid level, gave a new expression of the trait - resistance to curly top - in F_1 and F_2 hybrids. Analogous process of a new expression of curly top resistance in tetraploids in comparison with the diploids was observed also in the backcross generation, although 2 backcross tetraploid hybrids differed from each other (table 2).

Curly top resistance in 4n MS 91 x F_1	was	4.8919
Curly top resistance in 4n US 35/2 x F_1	was	3.4092
	Difference	1.4827

In both diploids and tetraploids, when the F_1 was crossed to the parent of low resistance (MS SLC 91), resistance in the backcross generation was reduced, but the grade of reduction differed greatly in diploid and in tetraploid hybrids. In the diploid hybrid, reduction in resistance was so marked that the b_1 generation did not differ in

resistance from the parent having low resistance, whereas the tetraploid backcross hybrid retained a resistance which exceeded significantly that of the parent with low resistance.

Data for resistance in backcross hybrids and in recurrent parents are tabulated below.

Generation	Diploid b_1 and b_2		Tetraploid b_1 and b_2	
	SLC 91 x F_1	US 35/2 x F_1	SLC 91 x F_1	US 35/2 x F_1
Backcross	7.6667	5.7295	4.8919	3.4092
Recurrent parent	7.8322	5.3779	7.7767	3.2643
Difference	0.1655	0.3516	2.8848	0.1449
msd	0.3896	0.3896	0.3896	0.3896
lsd	0.6462	0.6462	0.6462	0.6462

<u>Curly top resistance in the later generations of tetraploid monogerm and multigerm hybrids.</u>

A number of tetraploid self-sterile and self-fertile monogerm and multigerm strains was studied under severe curly top exposure at Jerome in 1961. Many of these strains were F_3 and F_4 hybrids. Although most of the strains had not been selected previously for curly top resistance (but had been selected for other characters such as type of seed, sucrose percent, yield, combining ability, etc.) many of them showed a good grade of resistance. Many tetraploid hybrids in later generations exceeded their resistant parent (tetraploid US 35/2) in curly top

resistance. Tetraploid US 401 was also higher in resistance than its diploid ancestor, US 401, which was killed by curly top. In the tetraploid strain US 401, many plants were injured by curly top, but by late fall they had developed good foliage and large roots.

It is often assumed that by increased number of loci, in which the hybrid segregates, the effect of segregation of individual genes is decreased. In 1933, Rasmusson put forward a hypothesis according to which the effect of every added gene decreases as the number of genes increases. This hypothesis probably does not hold for genes responsible for curly top resistance in diploids and partially in tetraploid sugar beets.

Summary.

Study of curly top resistance under a severe curly top exposure showed that the polygene complex, responsible for inheritance of curly top resistance, involves additive reactions of genes and also the effect of dominance and non-allelic gene reactions.

Maximum grade of curly top resistance will be obtained when selection for resistant strains is followed by selection based on the principles of combining ability.

Improvement of resistance to curly top was observed in many populations after they were turned into tetraploids by colchicine treatment.

Expression of genes responsible for curly top resistance, therefore, will be optimal at the tetraploid level for many populations.

Study of hybrids showed that F_2 tetraploid segregates were higher in curly top resistance than the F_2 diploid segregates in corresponding hybrids, although their parents were of the same origin.

I express my acknowledgement to Mr. Albert M. Murphy and to Mr. B. Ruffing for their help in conducting my experiments at Jerome since 1949 to 1961. These experiments enabled us to improve curly top resistance of the original parent SLC 101 in my first monogerm strains (SLC 91, SLC 123, etc.) on the base of which were obtained the first commercial monogerm hybrids; also, to increase resistance in monogerm self-fertile and self-sterile strains which were released to different sugar companies.

PRODUCTION OF TETRAPLOID STRAINS

By Helen Savitsky

Seed of 3 strains of sugar beet were treated by colchicine in 1961. Two of these strains with a certain amount of resistance to nematode were obtained from Charles Price, and 1 monogerm O-type highly curly top resistant inbred line was obtained from V. F. Savitsky.

Seedlings affected by colchicine were selected and grown in the greenhouse. They will be transplanted to the field for selection of tetraploid plants next summer.

EFFECTIVENESS OF SELECTION FOR TETRAPLOID PLANTS IN C_0 GENERATION ON THE BASIS OF THE NUMBER OF CHLOROPLASTS IN LEAF CELLS

By Helen Savitsky

Study of some characteristics in the leaves (chloroplasts, chromosomes, etc.) in the colchicine-treated generation (C_0) is a common method for selection of tetraploid plants. It is very important to determine the reliability of this method.

C_0 plants, grown from affected seedlings after colchicine treatment, were transplanted to a station field for selection of tetraploid plants. Tetraploid plants were selected on the basis of size of pollen grains in flowers developed on the main stem. Plants which developed large pollen grains (28-33μ) in all, or almost in all, flowers of the main inflorescence, were considered to be tetraploid. Actually, all plants in the treated generation (C_0) are to some extent chimeras, carrying both diploid and tetraploid tissues; but those plants which

develop a prevailing majority of diploid gametes in the flowers on the main inflorescence may be considered (for practical use) tetraploids, because they produce tetraploid progeny when pollinated by diploid pollen. Plants with smaller pollen grains in the flowers of the main inflorescence (19-22μ) were considered to be diploids.

The number of chloroplasts was counted in both guard cells of stomata in the leaves of the same seed stalk from which the anthers were examined for size of pollen grains. Chloroplasts were counted in 10 stomata cells of each plant. According to the average number of chloroplasts per stoma cell, plants were classified as falling into 1 of 3 groups, as follows: (1) plants having the number of chloroplasts corresponding to diploids (12 to 19). Such plants had mostly 13, 14, 15 or 16 chloroplasts per stoma cell. (2) Plants with a number of chloroplasts corresponding to tetraploids (24 or higher). (3) Plants with an intermediate number of chloroplasts (19 to 24). The last group might include diploid, as well as tetraploid plants. The number of chloroplasts in this group does not give a clear indication as to the level of ploidy of individual plants.

Seven different strains (5 self-fertile and 2 self-sterile) were examined for size of pollen grains and number of chloroplasts. Data obtained are shown in tables 1 and 2.

Fifty-five percent (55.5%) of the diploid plants had larger number of chloroplasts than should be presented in diploids. This indicates that the epidermal tissue was affected by colchicine to a greater degree than the subepidermal tissue. As a consequence, doubling of chromosomes occurred more often in the epidermis than in the tissues which produce sexual cells.

Table 1.--Number of chloroplasts in stomata cells of diploid C_0 plants.

Strain designation	Plants with number of chloroplasts corresponding to: Tetraploids	Diploids	Intermediate between tetraploids and diploids
	Number	Number	Number
537	4	17	2
301	5	5	3
171	13	8	3
127	15	1	1
509	3	3	4
573	45	43	7
202	19	23	1
Total	104	100	21
Percent	46.2	44.4	9.3

Table 2.--Number of chloroplasts in stomata cells of tetraploid C_0 plants.

Strain designation	Plants with number of chloroplasts corresponding to: Tetraploids	Diploids	Intermediate between tetraploids and diploids
	Number	Number	Number
537	42	8	14
301	46	2	6
171	57	4	10
127	30	0	3
509	9	1	3
573	69	16	7
202	22	6	6
Total	275	37	49
Percent	76.2	10.2	13.6
Grand Total			586

Among tetraploid plants, only 10.2 percent had the number of chloroplasts corresponding to their number in diploid plants. Also, 13.6 percent of plants showed lower number than tetraploids had to have. In other words, if selection of tetraploids was made on the base of chloroplast-number, 23.8 percent of tetraploid plants would be discarded.

At the same time, the group of tetraploid plants, selected from the whole population (586 examined plants), would consist of 275 true tetraploids plus 104 (27.4%) diploids. These 27.4 percent diploid plants would contaminate very highly the tetraploid population. Instead of obtaining in the next C_1 generation a pure tetraploid strain, the C_1 generation would contain many, if not a majority, of diploid and triploid plants. Much detailed work will be necessary for screening the plants with undesirable ploidy levels.

Leaf characteristics such as size of stomata cells, number of chloroplasts and even chromosome number, often used for selection of tetraploids, may be used in C_0 generation only for preliminary test and screening, if such a screening is really needed in some circumstances or climates. Final selection for tetraploids in C_0 generation must be based on direct selection of diploid gametes which will produce a tetraploid progeny. This gamete selection is highly effective (see report for 1960) and reduces work in chromosome counting in the following generations.

INTERSPECIFIC HYBRIDIZATION

By Helen Savitsky

Obtaining the first backcross progeny from hybrids between *Beta vulgaris* and nematode resistant species of the section *Patellares*.

Work in obtaining seed from F_1 tetraploid hybrids between tetraploid sugar beets and *B. patellaris*, and from triploid F_1 hybrids between tetraploid sugar beets and *B. procumbens*, was continued during the summer of 1961. Backcross seed was obtained after pollination of hybrid plants with sugar beet pollen. These seeds were planted in greenhouse in the fall and seedlings which came up were transplanted in nematode infected soil. Two hundred seventy first-backcross hybrid plants will be available now for examination to determine their degree of resistance to nematode. Selection of the most resistant plants will be made. The nematode resistance tests are being conducted in cooperation with Charles Price.

Chromosome number will be investigated in all first-backcross hybrids. After determination of nematode resistance and fixation of root tips for cytological study, the hybrid plants will be transplanted in the soil free from nematode for further growth and for study of different characters.

Study of the possibilities of transmission of the monogerm character from the species of the section *Patellares* to sugar beets.

It is a comparatively widely spread opinion that the monogerm character may be transmitted to sugar beets from the species of the section *Patellares*. Although the fruits of the 3 species of this section -

B. patellaris, B. procumbens and B. webbiana are single, cytological investigations show that these species are multigerm. The mode of. development of inflorescence in the section Patellares follows, with some deviations, the pattern of development of inflorescence in the multigerm races of the section Vulgares. The flowers, as in the multigerm races of the section Vulgares, develop in a cluster. Several flowers start to develop from a common peduncle, but in contrast to multigerm Vulgares races, each flower develops its own pedicel and grows separately, forming an umbel. After the fruits ripen, the pedicels break and single fruits are released.

In the monogerm races of the species B. vulgaris only a single flower and a single fruit are developed from one peduncle.

To study the possibility of obtaining monogerm fruits from hybridization with the species of the section Patellares, diploid monogerm sugar beets were crossed with diploid B. procumbens. The F_1 hybrid plants failed to develop on their own roots, as usual, and were grafted to sugar beet plants. Fifteen F_1 grafted hybrids, derived from different matings, were grown to flowering stage. All of these hybrids developed multigerm inflorescences. Flowers grew in clusters, on a common peduncle, and the type of development did not differ from that of inflorescences of the hybrids between multigerm sugar beets and species of the section Patellares. Like the hybrids with multigerm beets, the hybrids with monogerm beets developed a type of inflorescence intermediate between section Vulgares and section Patellares. Individual flowers grew separately on a common peduncle, but they did not develop pedicels like their wild parents. The basal parts of flowers were connected with but not inbedded in the tissues of peduncle.

The few fruits that developed on these F_1 hybrids were compound and did not differ morphologically from the fruits obtained from multigerm F_1 hybrids with corresponding species.

The species of the section Patellares, therefore, do not carry the gene for the monogerm character. They possess a basically different type of inflorescence in which flowers and fruits develop in cluster, but on separate pedicels and are easily shed after ripening.

The type of multigerm development was dominant over monogerm development, as in crosses of monogerm and multigerm beets within the species *B. vulgaris*. At the same time, the type of inflorescence in F_1 hybrids was intermediate between Vulgares and Patellares.

True monogerm races cannot be obtained from hybridization of multigerm, or even monogerm sugar beets with species of the section Patellares. Such hybridization will produce only sugar beet races with multigerm inflorescence of an intermediate type between section Vulgares and Patellares, or perhaps with some slight deviations from the basic type of inflorescence of either one of the mentioned sections.

[illegible] that developed on these F_1 hybrids were composed [illegible] morphologically and the fruits obtained from multi- hybrids with [illegible] being species.

The [illegible] of the section Patellares therefore do not carry genes for the monogerm character. They possess a basically different inflorescence in which flowers and fruits develop in cluster, [illegible] the pedicels and are easily shed after ripening.

The type of multigerm development was very common [illegible] development, as in crosses of monogerm and [illegible] roots within the vulgaris. [illegible] the same lines, the [illegible] difference in [illegible] as in crosses [illegible] between vulgaris and patellaris.

[illegible] monogerm [illegible] cannot be obtained from hybridization of multi- [illegible] even monogerm sugar beets with species of the section Patellares. [illegible] will produce only sugar beet types with multigerm [illegible] of an intermediate type of the section Vulgares and [illegible] or perhaps with some slight deviations from the basic type inflorescence of either one of the mentioned sections.

[illegible]

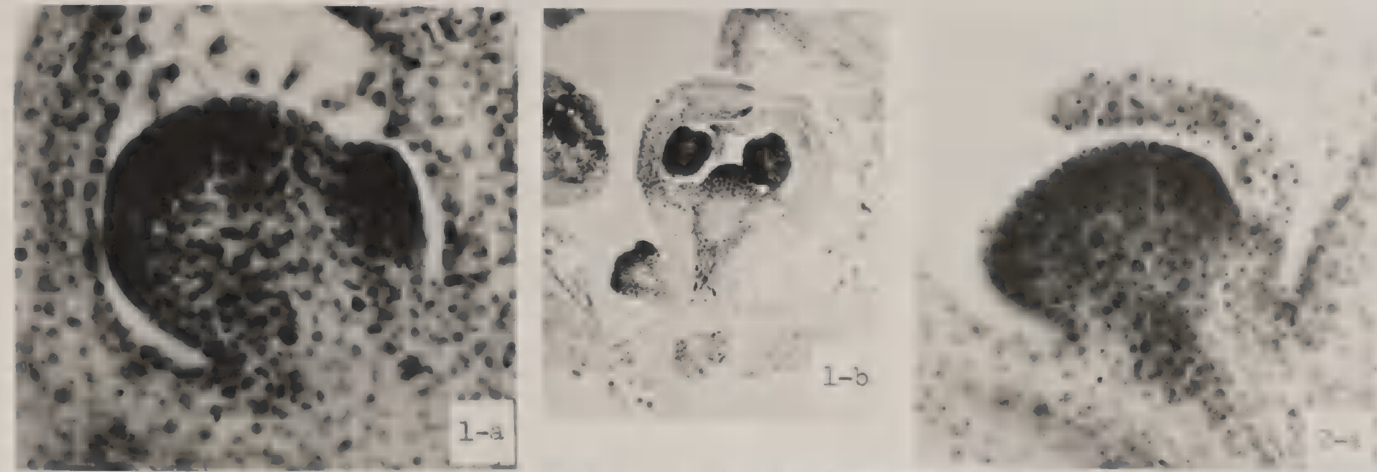


Figure 1.--Beta patellaris showing (a) development of a second receptacle on a common peduncle; (b) a second bud growing from the common peduncle; (c) two flowers in a cluster on separate pedicels.

Figure 2.--Monogerm Beta vulgaris showing (a) one receptacle on a peduncle; and (b) one flower developed on a peduncle.

Figure 3.--F_1 hybrid of monogerm B. vulgaris with B. procumbens showing a cluster of buds, the basal parts of which are connected by the tissue of the peduncle.

PART VIII

NEMATOLOGY INVESTIGATIONS

Foundation Project 13

Arnold E. Steele

Nematology Investigations, Crops Protection Research Branch
ARS, USDA, Salinas, California

NEMATOLOGY INVESTIGATIONS BY ARNOLD E. STEELE, 1961
(A phase of Foundation Project 13)

Progress report on the implementation of microplots in studies to determine the efficacy of various legume crops in controlling *Heterodera schachtii*.

Studies of cyst nematode populations in field plots are made difficult by within-plot variations in nematode populations caused by transport of cysts and eggs by water, soil insects, and cultivation equipment, multiplication of nematodes on susceptible weed hosts, and variation of soil type within the experimental field.

Jones (1955, 1956) found that some of the difficulties associated with population studies using field plots were overcome when microplots were used. Microplots described by this worker were constructed of slotted concrete posts and paving stones joined together with bitumastic, and measured 2 feet 4 inches square and 2 feet deep.

Microplots were established in a field at the U.S. Agricultural Research Station, Salinas, California to study effects of various crops on population of the sugar beet nematode. Bins, measuring 4 feet square and 3 feet deep, were constructed of 3/4" x 12" redwood held with aluminum nails, lined with polyethylene plastic sheeting, and then sunk into the ground to a depth of 2 1/2 feet. The bins, serving as microplots, were placed 4 feet apart and arranged so that infested microplots would be relatively isolated from non-infested ones, the arrangement within the infested and non-infested areas being in a latin square design. No nematode cysts were recovered from soil samples obtained from this field.

Sugar beets(*Beta vulgaris* L. var. US 75) were grown in individual aluminum foil cylinders containing steam sterilized soil. When the plants were well established, the aluminum foil was removed and 16 beets transplanted to each bin. Infested soil was added to one-half of the microplots at the time the beets were transplanted.

Soil samples were obtained from each plot on March 9, 1961, after beets had been removed. The samples were oven dried, weighed, and processed to recover cysts. None of the samples from non-infested plots contained cysts. Cyst counts of samples from infested plots are presented in table 1.

The following leguminous crops were planted on April 27, 1961, with each crop being replicated 5 times in a randomized block design: Kentucky wonder white-seeded pole beans (Phaseolus vulgaris L.), small white navy beans (Phaseolus vulgaris L.), telephone dark poded peas (Pisum sativum), White Dutch clover (Trifolium repens), and Chilean alfalfa (Medicago sativa). Each plot receiving peas or beans contained 4 planting rows spaced 1 foot apart, while seed of clover or alfalfa were broadcast planted.

Stand, yields, and yields corrected to stands of peas and beans appear in table 4. No yield data were obtained from alfalfa or clover.

In order to obtain information on the viability of the nematode populations, random samples were obtained from the microplots on October 25, 1961, and placed in 6-inch pots in the greenhouse, each pot receiving one sugar beet seedling. Data on this viability test is not yet available. At the same time, cyst counts were made for each of the samples, and the results appear in table 2. The effects of the various crops on decline of cyst populations are recorded in table 3.

There were little differences in yield data between infested and non-infested plots of beans or peas. None of the treatments gave significant differences in cyst populations or in decline of cyst populations, although beans or peas appear to have effected greater reductions than clover or alfalfa. Data on the viability of nematode populations, when available for evaluation, will determine whether plots will be later planted to legume crops or beets.

Table 1. Numbers of cysts of *Heterodera schachtii* per 100 grams of soil sampled on March 9, 1961.

		Replications						
		1	2	3	4	5	Total	Average
Navy beans	I	42	46	40	63	56	247	49.4
Clover	II	38	52	64	36	57	247	49.4
Alfalfa	III	36	49	59	67	35	246	49.2
Pole beans	IV	47	62	31	50	51	241	48.2
Peas	V	42	62	37	64	39	244	48.8
Total		205	271	231	280	238	1,225	

Not significant

Table 2. Effect of various legumes on cyst nematode populations in microplots sampled October 25, 1961.

Navy beans	I	18.7	23.3	30.7	26.6	22.7	122.0	24.4
Clover	II	26.0	40.0	62.0	22.0	28.0	178.0	35.6
Alfalfa	III	30.0	34.7	37.3	31.3	24.7	158.0	31.6
Pole beans	IV	26.0	23.3	17.3	28.7	26.6	121.9	24.4
Peas	V	30.0	40.0	18.0	17.3	24.7	130.0	26.0
Total		130.7	161.3	165.3	125.9	126.7	709.9	

Not significant

Table 3. Effect of various legumes on decline of cyst populations in microplots, 1961.

Navy beans	I	57.9	49.3	23.3	57.8	59.5	247.8	49.6
Clover	II	31.6	23.1	3.1	38.9	50.9	147.6	29.5
Alfalfa	III	16.7	29.2	36.8	53.3	29.4	165.4	33.1
Pole beans	IV	44.7	62.4	44.2	42.6	47.8	241.7	48.3
Peas	V	28.6	35.5	51.4	73.0	36.7	225.2	45.0
Total		179.5	199.5	158.8	265.6	224.3	1,027.7	

Not significant

Table 4. Stands and yields of peas and beans grown in beet nematode-infested or non-infested microplots, 1961.

	No. plants/plot		Yield/plot (gms.)		Yield/plant (gms.)	
	Infested	Non-infested	Infested	Non-infested	Infested	Non-infested
			Kentucky wonder pole beans			
1	45	53	1,582	1,512	35.2	28.5
2	45	45	1,554	1,415	34.5	31.4
3	48	48	1,426	1,385	29.7	28.9
4	48	56	1,415	1,325	29.5	23.7
5	50	51	1,324	1,279	26.5	25.1
Total	236	253	7,301	6,916	155.4	137.6
			Small white navy beans			
1	68	57	3,074	3,043	45.2	53.4
2	55	53	2,839	3,011	51.6	56.8
3	56	65	2,644	2,664	47.2	41.0
4	61	54	2,409	2,331	39.5	43.2
5	59	92	2,179	2,244	36.9	43.2
Total	299	321	13,145	13,293	220.4	237.6
			Telephone dark poded peas			
1	32	33	1,431	1,402	44.7	42.5
2	32	38	1,414	1,379	44.2	36.3
3	43	29	1,309	1,240	30.4	42.8
4	19	27	861	1,118	45.3	41.4
5	27	35	795	1,095	29.4	31.3
Total	153	162	5,810	6,234	194.0	194.3

Effects of root diffusates of various nematode-resistant and susceptible lines of sugar beet (Beta vulgaris L.) on emergence of larvae from cysts of Heterodera schachtii.

Certain selected breeding lines of sugar beet (Beta vulgaris L.) have shown various degrees of resistance to the sugar beet nematode, Heterodera schachtii (Price and Smith, this report). However, the nature of the nematode resistance in both these beets and in certain wild Beta species is not known. This resistance may or may not have a common basis; but in any case it would be helpful, especially in the breeding program, to understand the nature of the resistance to the sugar beet nematode.

Golden (1958) found that root diffusates of Beta patellaris Moq., B. procumbins Chr. Sm., and B. webbiana Moq. contained effective hatching factors. In the test reported below, root diffusates of resistant and susecptible lines of sugar beet were compared for their effects on emergence of larvae from cysts of H. schachtii.

Materials and Methods

Root diffusates of four lines of nematode-resistant and two lines of nematode-susceptible sugar beets were tested. Two hundred ml of root diffusate were leeched from 5-inch pots containing 3 plants of a single line growing in sterilized soil. All diffusates were diluted 1 to 10 with water in order that slight differences in hatching effect could be detected. Treatments were replicated 4 times in individual Syracuse watch glasses, each of which contained 40 cysts. At weekly intervals the nematode cysts were transferred to clean watch glasses containing fresh treatment solutions. The emerged larvae were preserved in 5% formalin until counted, at which time those samples containing large numbers of larvae were aliquoted. Results were analysed for statistical

significance by the "analysis of variance" method.

Results and Conclusion

The numbers of larvae emerging in each of the diffusate treatments were not significantly different. The larvae obtained from diffusates of nematode resistant lines averaged 10,390, 9,200, 8,410, and 7,990 larvae per replication; whereas those from the susceptible lines averaged 9,060 and 8,130 larvae per replication. The total number of larvae emerging in 4 replications of tap water treatment was 3,090. Diffusates of all resistant lines tested contained strong hatching factors, as did the susceptible ones; consequently, resistance in these lines must be attributed to other factors.

Additional studies of the effects of nabam solutions on the emergence of larvae from cysts of Heterodera schachtii.

In previously reported tests (Annual Report, 1960), the author found that solutions containing 1,000 ppm (parts per million) of nabam (disodium ethylene bis dithiocarbamate) increased hatching of Heterodera schachtii larvae as compared with tap water controls but only 60% as much as sugar beet root diffusate. Addition of 1,197 ppm of manganese sulphate or 1,316 ppm of zinc sulphate reduced the action to about the same as tap water. Nabam at concentrations of 2,000 ppm inhibited hatching of sugar beet nematode larvae.

Since nabam has recently been marketed as a wettable powder (Dithane A-40), a test was undertaken to compare the effects of this material and the liquid nabam previously tested. In addition, attempts were made to determine if hatching is permanently inhibited by concentrations of nabam exceeding 2,000 ppm and if stimulatory effects of 1,000 ppm nabam would be retained after removal of the treatment solution.

Materials and Methods

In the first of 2 tests, 7 different treatments were tested for effects on emergence of larvae from cysts of Heterodera schachtii. Each treatment contained 4 replications, each consisting of 40 cysts. Cysts in 5 of the treatments were kept 7 weeks in either tap water, beet-root diffusate, 1000 ppm or 4,000 ppm nabam (Dithane D-14, a liquid formulation), or 1,000 ppm nabam (Dithane A-40). Cysts for the other 2 treatments were kept one week, with either 1,000 ppm or 4,000 ppm nabam,after which they were transferred to tap water where they remained an additional 6 weeks. Collection of diffusate and conduct of the test were essentially the same as described in other reports. Counts of larvae emerged from cysts are listed in tables 5 and 6.

A second test consisted of drenching various treatment solutions on soil contained in cylindrical paper cartons of 2-quart capacity. Each carton measured 3.5 inches by 13.5 inches. Prior to application of the treatments, 3 tea bags, each containing 50 cysts, were placed in each of 36 cartons 1, 6, or 12 inches below the soil surface.

Treatments consisted of tap water, beet root diffusate, 1,000 ppm or 2,000 ppm nabam, 1,000 ppm nabam plus 658 ppm zinc sulphate, or 2,000 ppm nabam plus 1,316 ppm zinc sulphate. The treated cartons were kept in a utility room. The temperature of the treated soil remained at about 65°F. Ten days after treatment the cartons were removed to the laboratory where the cysts were recovered and placed in Syracuse watch glasses containing about 15 ml of beet diffusate. The cysts were treated with diffusate for a period of 3 weeks to induce hatching and emergence of larvae from the cysts. Counts of larvae are listed in table 7. Data on both tests were analyzed for statistical significance by the "analysis of variance" method.

Results and Conclusions

Treatment of root nematode cysts with 4,000 ppm of nabam inhibited emergence of larvae. However, considerable numbers of larvae emerged from cysts in tap water after the cysts were removed from the inhibiting solutions. This indicates that inhibition occurs only as long as the cysts are exposed to this concentration of nabam,and possibly a breakdown product of nabam might be responsible for the stimulating effect. Dithane A-40 gave greater hatches during the first week than did Dithane D-14, suggesting possibly that Dithane A-40 may release a stimulatory breakdown product quicker while decomposing at a more rapid rate than does Dithane D-14.

Results of the second test indicate that soil drenches of beet diffusate

was the only treatment that noticeably stimulated emergence of larvae from cysts and this treatment was most effective on cysts placed 6 inches below the soil surface. The effects of all nabam treatments were similar to the effects of tap water. Absorption of nabam or its breakdown products by soil may be contributing factors to the failure to obtain increased larval emergence from cysts in soil.

Table 5. Number of larvae emerged from cysts of Heterodera schachtii treated 7 weeks with the indicated solutions.

Treatment[1/]	Conc. (ppm)	Replication 1	2	3	4	Total	Average
1 Nabam	4,000	6	12	1	17	36	9.0
2 Tap water	--	433	1,320	654	552	2,959	739.8
3 Nabam	1,000	2,384	1,364	1,398	2,431	7,577	1,894.3
4 Nabam	4,000	2,232	1,438	2,784	2,676	9,130	2,282.5
5 Nabam	1,000	3,541	3,676	4,639	3,604	15,460	3,865.0
6 Nabam	1,000	4,790	4,661	4,380	5,258	19,089	4,772.3
7 Beet diff.	--	6,952	6,997	7,201	8,857	30,007	7,501.8
Significance							**
LSD .05							793.1

Table 6. Effect of various treatments on emergence of larvae from cysts of Heterodera schachtii[2/]

Treatment[1/]	Conc. (ppm)	1st week	Last 6 weeks	Total	Average
1 Nabam	4,000	9	27	36	9.0
2 Tap water	--	1,784	1,175	2,959	739.8
3 Nabam	1,000	5,935	1,642	7,577	1,894.3
4 Nabam	4,000	15	9,115	9,130	2,282.5
5 Nabam	1,000	7,209	8,181	15,460	3,865.0
6 Nabam	1,000	5,283	13,804	19,087	4,772.3
7 Beet diff.	--	10,207	19,800	30,007	7,501.8

1/ Treatment 5 consisted of Dithane A-40. All other nabam treatments were Dithane D-14. Cysts of treatments 3 and 4 were treated one week with the indicated solutions followed by treatment with tap water for 6 weeks.

2/ Total number of larvae in 4 replications.

Table 7. Emergence of larvae from cysts of <u>Heterodera schachtii</u> in beet diffusate as influenced by various soil treatments.1/

Depth of cysts (inches)	Tap water	Nabam 1,000 ppm	Nabam 2,000 ppm	Nabam 1,000 ppm + 658 ppm Zn SO4	Nabam 2,000 ppm + 1,316 ppm Sn SO4	Beet diffusate	Total	Average
1	326.3	311.1	322.0	299.6	319.0	126.4	1,704.4	284.1
6	313.2	316.3	298.4	346.9	313.4	83.7	1,671.9	278.7
12	319.5	344.7	339.8	347.6	341.8	209.4	2,002.8	333.8
Total	959.0	972.1	960.2	994.1	974.2	519.5	5,379.1	
Average	319.7	324.0	320.1	331.4	324.7	173.2		
Significance						*		
LSD .05						72.6		

1/ Number of larvae per cyst - average of 6 replications.

Effects of pretreatment of *Heterodera schachtii* cysts with sugar solutions on emergence of larvae in sugar-beet root diffusate.

Feder (1960) reported that 100% of the nematodes of 4 species tested were killed by immersion for 1 hour in 40 or 50% sucrose solution. He did not include any species of the genus *Heterodera*. This paper reports the results of experiments on the effects of sucrose on the emergence of larvae from cysts of the sugar beet nematode, *Heterodera schachtii* Schmidt.

Materials and Methods

The test consisted of treating groups of 50 cysts with sugar (sucrose) solutions or tap water for 96 hours at room temperatures (70° to $80^{\circ}F$). The sugar concentrations ranged from 0.1% to 60.0% as shown in table 8.

Each treatment was replicated 4 times. Groups of cysts which received treatments 6-9 (table 8) were placed in tea bags and submerged in vials containing the sugar solutions because of the tendency of the cysts to float. Cysts of all other treatments were placed in Syracuse watch glasses. After the initial treatment the cysts were removed and placed in tap water for 24 hours to allow the sugar solutions to diffuse out. Floating cysts and cysts broken in handling were discarded, and the larvae which emerged during this process were counted. Following this tap water treatment, the cysts were rinsed in tap water and placed in watch glasses containing sugar beet root diffusate or tap water for 6 weeks under conditions describdd by Golden (1958) for other hatching tests. The numbers of larvae emerged in each of the various treatments were adjusted to the equivalent hatch of 50 cysts (Table 8) and analyzed for statistical significance by the "analysis of variance" method.

Results and Discussion

Complete inhibition of emergence in sugar solutions occurred in treatments containing 30% or more of sugar (Table 8). After transfer from sugar solutions to tap water, significantly fewer larvae emerged from cysts pretreated with 50 or 60% sugar solutions than from cysts treated with water. However, the highest sugar concentration tested reduced the hatch by only 40%.

Fairbairn (1960) cited a number of studies wherein eggs of several nematode species were found to be highly impermeable to solutions of salts or sucrose. Dropkin et al. (1958) demonstrated that normal hatching of nematode eggs occurred after removal from inhibiting solutions of salt or dextrose.

The results of the present test suggest that eggs of *H. schachtii* are impermeable to solutions containing high concentrations of sucrose. Consequently, control of the beet nematode by addition of sugar to the soil is probably not practical.

Table 8. Average number of Heterodera schachtii larvae emerged from cysts which had been pretreated with various sucrose solutions in 4 replications.

Treatment No.	Percent sucrose	Number of larvae emerging: In sugar solution	Number of larvae emerging: In tap water	In beet root diffusate*	Total
1	0.1	259	198	8,538	8,995
2	1.0	227	8	8,510	8,745
3	5.0	27	3	8,765	8,795
4	10.0	35	13	8,548	8,596
5	20.0	218	17	9,363	9,598
6	30.0	0	1	9,005	9,006
7	40.0	0	9	8,358	8,367
8	50.0	0	10	7,238	7,248
9	60.0	0	0	6,103	6,103
10	0	-	1,875	10,210	12,085
11	0	-	6,147		6,147

LSD at .05 level 2,300.7

*Figures given for treatments 1-10 are numbers of larvae which emerged in beet diffusate after cysts were pretreated with the indicated sugar solutions. In treatment 11, cysts were immersed in tap water throughout the test.

The effect of removal of eggs from cysts on hatching of larvae of *Heterodera schachtii*.

Various workers have suggested that hatching of cyst nematode eggs may be influenced by oxygen concentration. Wallace (1955) demonstrated that emergence of larvae from cysts of *H. schachtii* was decreased by exposure of cysts to low oxygen concentration for short periods of time. According to Christie (1959), T. B. Onions, working with *H. rostochiensis*, found that eggs near the cyst wall hatch more rapidly than those near the center of the cyst, which he attributed to a gradient of oxygen tension within the cyst. Wallace (1956) found that rate of larval emergence increases with aeration of the soil environment. These observations suggest that the rate of hatching of beet nematode eggs might be increased if the eggs were removed from cysts.

In laboratory tests larval emergence from cysts treated with tap water varies from 5 to 25% of larval emergence from cysts treated with beet root diffusate. The test reported below was designated to determine if removal of eggs from cysts would increase larval hatch in tap water.

Materials and Methods

Cysts of *Heterodera schachtii* were divided into 3 groups, each consisting of 8 replications of 20 cysts. Two of the cyst groups were placed in Syracuse watch glasses containing tap water or beet root diffusate where they were allowed to remain for 3 weeks. At the end of the treatment period, the emerged larvae were counted and the cysts broken open to obtain counts of hatched larvae which had not emerged from the cysts. Eggs and larvae were removed from cysts of a third group and the empty cysts discarded. Hatched larvae were counted and the eggs placed in tap water for 3 weeks. The number of emerged larvae obtained in this test appear in table 9.

Results and Conclusion

Removal of eggs from cysts resulted in an average increase in hatch in tap water of about three larvae per cyst. The increase in hatch was equivalent to less than 2% of the number of larvae emerged from cysts treated with beet diffusate.

Table 9. The effect or removal of eggs from cysts on hatching of larvae of *Heterodera schachtii*.

Treatment	REPLICATIONS 1	2	3	4	5	6	7	8	Total
1. Eggs in tap water									
Larvae removed from cysts	219	358	552	435	245	139	184	295	2,427
Larvae hatched from eggs	759	540	297	303	471	444	361	402	3,577
Total larvae	978	898	849	738	716	583	545	697	6,004
2. Cysts in tap water									
Larvae emerged from cysts	399	557	765	945	534	921	625	334	5,080
Larvae left in cysts	75	70	120	30	50	52	23	42	462
Total larvae	474	627	885	975	584	973	648	376	5,542
3. Cysts in beet diffusate									
Larvae emerged from cysts	4,384	3,932	3,973	3,288	4,835	4,056	3,970	4,101	32,539
Larvae left in cysts	5	3	4	10	116	9	5	9	161
Total larvae	4,389	3,935	3,977	3,298	4,951	4,065	3,975	4,110	32,700

LITERATURE CITED

1. Christie, J. R. 1959. Plant Nematodes. Their Bionomics and Control. Agri. Exp. Stations, University of Fla., Gainesville. 256 pp.

2. Dropkin, V. H., G. C. Martin, and R. W. Johnson. 1958. Effect of osmotic concentration on hatching of some plant-parasitic nematodes. Nematologica 3:115-126.

3. Fairbairn, D. 1960. The physiology and biochemistry of nematodes. In Nematology: fundamentals and recent advances. Edited by J. N. Sasser and W. R. Jenkins. University of North Carolina Press. Pages 267-297.

4. Feder, W. A. 1960. Osmotic destruction of plant-parasitic and saprophytic nematodes by the addition of sugars to soil. Plant Disease Reptr. 44:883-885.

5. Golden, A. M. 1958a. Influence of leaf diffusate of sugar beet on emergence of larvae from cysts of the sugar-beet nematode (Heterodera schachtii). Plant Disease Reptr. 42:188-193.

6. Golden, A. Morgan. 1958b. Interrelationships of certain Beta species and Heterodera schachtii, the sugar-beet nematode. Plant Disease Reptr. 42: 1157-1162.

7. Jones, F. G. W. 1955. A microplot technique for the study of soil populations of cyst-forming root eelworms of the genus Heterodera. Soil Zoology. Pp. 390-393.

8. Jones, F. G. W. 1956. Soil population studies using microplots. Nematologica 1:2:109-110.

9. Wallace, H. R. 1955. Factors influencing the emergence of larvae from cysts of the beet eelworm, Heterodera schachtii Schmidt. J. Helm. 29: 3-16.

10. Wallace, H. R. 1956. The emergence of larvae from cysts of the beet eelworm, Heterodera schachtii Schmidt, in aqueous solutions of organic and inorganic substances. Am. Appl. Biol. 42: 274-282.

PART IX

BREEDING FOR NEMATODE RESISTANCE

and

SCREENING TESTS IN FIELD AND GREENHOUSE

Foundation Project 13

Charles Price

C. H. Smith

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON THE PLANT BREEDING FOR RESISTANCE TO SUGARBEET NEMATODE AND RELATED STUDIES OF THE CONTROL OF SUGARBEET NEMATODE

(Foundation Project 13)

By Charles Price

Breeding for resistance to sugarbeet nematode has received major emphasis at Salinas, California. The greenhouse method used at Salinas for selecting for nematode resistance was described in the 1960 report. Some modification of this method has been followed this season. Briefly, the technique involves plants grown in heavily infested soil in flats and then transferred to infested soil in aluminum cylinders. Figure 1 shows comparison of US 41 and selection 133-3. The best plants are selected and subjected to additional infestation in larger pots. The final selections are grown to seed for further evaluation and test and crossing with promising lines. These crosses are tested in field and greenhouse; and selections were made from breeding stock which showed the highest resistance to sugarbeet nematode in the previous year. Several cycles have been completed in some lines, and cycles are continued as time and space permits.

Complexities involved in breeding for resistance to nematode are confounded by the presence of yellows, mosaic, root rot, curly top, and other diseases of sugarbeets. It is, therefore, evident that selections should be made under exposure to combination of diseases. Field tests of greenhouse selected material are made and further selections are made in the field. Root rotting organisms play an

important part in damage from nematode in fields in which sugarbeets are grown for sugar, and organisms in the soil which cause root rot are present in most soils. Nematodes are undoubtedly responsible, to a large extent, for entrance of organisms in beet tissue through punctures made by the nematodes. A variety of sugarbeets which is resistant to combination of root rot and nematode is, therefore, highly desirable. This phase of the work has received much attention in the breeding program at Salinas. Soil which is known to contain organisms causing root rot is thoroughly mixed with soil containing cysts of the nematode. Screening tests are made in the greenhouse under conditions of exposure to root rot and nematodes. By means of repeated selections and crosses, some lines have been developed which show remarkable resistance to combination of root rot and nematodes.

To determine losses caused by sugarbeet nematode, alone or in combination with yellows and root rot, studies under controlled conditions were made in crocks in the greenhouse and in the field. In these studies, selected nematode resistant lines 834 and 850-6 were compared with the commercial variety US 41 used as check. The test beets were grown in 3-gallon crocks in nematode-free and nematode-infested soil and subjected to infection with yellows and root rotting organisms. In the nematode-free soil control, beets were grown in sterilized soil; and in nematode-infested soil, nematode cysts were added to the sterilized soil. In crocks in which damage to beets from root rot was measured, soil known to contain root rotting organisms was added to the sterilized soil and to the nematode-infested soil. In

Figure 1. Second generation of selection for resistance to combination of root rot and nematode. Reduction of stand is substantially more in US 41 than in selection 133-3. Nematode cysts and root rotting organisms were added to soil in flats prior to transplanting seedlings.

crocks in which the damage from yellows was measured, beets were infected by means of the green peach aphid, Myzus persicae. The aphids were produced on radish plants and transferred to yellows-infected sugarbeet plants 24 hours before being transferred to beets to be infected with yellows. The aphids for these studies were kindly furnished by Dr. C. W. Bennett.

The results of these tests are shown in Table 1.

The results given in Table 1 show comparisons between US 41, 834, and 850-6 grown in nematode-free and nematode-infested soil and subjected to infection with beet yellows and root rotting organisms.

These results show that lines 834 and 850-6 yielded significantly more than US 41 in both nematode-free and nematode-infested soil at the 1% level of significance. However, the yield of US 41 in nematode-free soil was much closer to yields of 834 and 850-6 when yellows and rot were not involved. In lines 850-6 and 834 there was no significant difference in yield of beets grown in nematode-free and nematode-infested soil either in presence or in absence of root rotting organisms. There was a significant reduction in yield of beets subjected to virus yellows both in nematode-infested and nematode-free soil.

In US 41 there was a significant reduction in yield caused by nematode, alone or in combination with yellows and root rot.

On the basis of these tests, the nematode-resistant selections grown in nematode-infested soil showed significantly less damage from beet yellows and root rot than commercial variety US 41 which was used as check. In some field tests under exposure to sugarbeet nematode, US 41 has shown moderate tolerance to nematode compared with other

Table 1. EFFECTS OF NEMATODE RESISTANCE IN SUGARBEETS ON DAMAGE BY NEMATODES, BEET YELLOWS, AND ROOT ROT

VARIETY OR LINE	NEMATODES IN SOIL	DISEASE CONDITION AV. WT. PER BEET			LOSS DUE TO DISEASE		LDS	
		CONTROL Grams	ROOT ROT Grams	BEET YELLOWS Grams	ROOT ROT Percent	BEET YELLOWS Percent	Grams	Percent
	FREE	709.8	692.0	610.33	2.5	14.0	36.87	5.2
850-6	INFESTED	679.8	668.0	578.5	1.7	13.4		
	LOSS %	4.2	3.6	5.2				
	FREE	722.5	709.7	613.5	1.8	15.1	39.66	5.5
834	INFESTED	685.0	664.5	570.5	3.0	16.7		
	LOSS %	5.2	6.4	7.0				
	FREE	671.6	586.0	566.5	12.7	15.6	37.24	5.5
US 41	INFESTED	491.0	364.0	353.3	25.9	28.0		
	LOSS %	26.9	37.9	37.6				

commercial varieties. Differences in yield of US 41 and nematode-resistant lines will vary according to exposure to diseases other than nematodes. US 41 has a high degree of resistance to curly top and, unless lines developed for resistance to nematode are also resistant to curly top, the yields will be low under conditions of curly top exposure either in nematode-infested or nematode-free soil. This probably would also be true with exposure to other diseases for which the lines have no resistance.

Much work is necessary to develop lines of sugarbeets which are resistant to combination of nematodes and other disease prevalent in the areas in which sugarbeets are grown. It is hoped that the work under way at the Salinas Station will open the way to commercial development of sugarbeet varieties resistant to the sugarbeet nematode. Hybrids developed by Mrs. Helen Savitsky by crossing cultivated sugarbeets and wild species are being tested at Salinas, and the most promising material is being screened for nematode resistance.

Testing Breeding Material in Field.

An evaluation test with nematode-resistant lines and a commercial variety (US 41), used as check, was conducted in a field at the U. S. Agricultural Research Station, Salinas, California. A large population of the sugarbeet nematode has been built up in the soil by means of adding to the soil large numbers of nematode cysts which had been screened from the soil in a commercial field in which extreme damage to sugarbeets had resulted. To further increase the population of nematodes in

the test field, sugar beets were planted prior to the test. To determine the uniformity of the infestation, beets were carefully removed from the soil and the roots examined for presence of female nematodes. It was found that the infestation of the soil was uniform and severe, judging from the large numbers of nematodes on all beets examined. Differences in foliar growth between some lines bred for resistance to nematode and US 41, used as check, were observed in the test plot. (Figure 2). Yields of roots also were significantly different among the lines tested. (Table 2).

Referring to Table 2, it is seen that yields of roots in tons per acre of 66 lines were higher than US 41. The increases in yield vary from 8.670 tons and 75.1% to .087 tons and 3.0%. Seventeen lines yielded lower than US 41. The results of this test indicate that some of the nematode-resistant lines have possibilities in the breeding program, while others do not. It has been pointed out that combinations of disease factors have a profound influence on the ability of a line to yield satisfactorily. In this test the beets were exposed to all the diseases prevalent during the growing season. It should also be pointed out that the beets in this test were planted late in the season so as to secure maximum damage from sugarbeet nematode.

In California, sugarbeets planted in winter, when nematodes are less active, withstand attack from nematodes much better than late-planted beets. The yield of beets planted on heavily infested soil with susceptible varieties may be increased to an appreciable amount if the beets are planted in winter, as compared with spring plantings.

Figure 2. Field test of nematode resistant lines of sugarbeet compared with check (US 41) under condition of heavy exposure to sugarbeet nematode. Two rows in front of white board are resistant line 019 on left and US 41 on right.

Table 2. SUGARBEET NEMATODE RESISTANCE EVALUATION TEST,

SALINAS, CALIFORNIA, 1961

Variety or Line	Acre Yield Tons	Increase Acre Yield over Check (US 41) Tons	Percent	Beets per 100 ft. row Number
1033-1	20.216	8.670	75.1	117
057-10	19.083	7.537	65.3	132
857-3	18.821	7.275	63.0	126
033-1	18.299	6.753	58.5	141
C076-6	18.037	6.491	56.2	117
059-8	17.773	6.227	53.9	120
801-7	17.645	6.099	52.8	114
U074	17.515	5.969	51.7	126
802-23	17.514	5.968	51.7	138
C057-15	17.253	5.707	49.4	123
861-25	16.992	5.446	47.2	111
801-13	16.599	5.013	43.4	114
060	16.469	4.923	42.6	129
857-5	16.208	4.662	40.4	123
054-1	16.070	4.524	39.2	123
019	15.946	4.440	38.5	117
90.107	15.946	4.440	38.5	111
10896	15.946	4.440	38.5	112
060-3	15.684	4.138	35.8	129
801-3	15.554	4.008	34.7	123
B075	15.423	3.877	33.6	111
1089B	15.162	3.616	31.3	99
801-12	15.162	3.616	31.3	120
1033-1	14.901	3.355	29.1	96
860-4	14.770	3.224	27.7	120
90.105	14.650	3.104	26.9	108
063	14.639	3.093	26.8	114
860-7	14.509	2.963	25.7	99
C034	14.377	2.791	24.2	108
C028	14.377	2.791	24.2	105
C050-6	14.290	2.744	23.8	135
39(901)	14.247	2.701	23.4	126
861-17	14.116	2.570	22.3	111
859-3	14.116	2.570	22.3	120
062-15	14.116	2.570	22.3	111

Table 2 - Continued

Variety or Line	Acre Yield Tons	Increase Acre Yield over Check (US 41) Tons	Percent	Beets per 100 ft. row Number
C032	14.114	2.568	22.2	105
033-3	13.942	2.396	20.8	117
862-3	13.724	2.178	18.9	120
801-2	13.724	2.178	18.9	114
90.5	13.724	2.178	18.9	111
A050-6	13.593	2.047	17.7	108
802-13	13.462	1.916	16.6	117
C056-1	13.419	1.873	16.2	117
033	13.332	1.786	15.5	111
075	13.330	1.784	15.5	112
054-2	13.071	1.525	13.2	108
892-5	13.070	1.524	13.2	117
834-1	12.940	1.394	12.1	114
862-7	12.940	1.394	12.1	105
033-1	12.940	1.394	12.1	101
834-2	12.940	1.394	12.1	104
980-23	12.940	1.394	12.1	105
062-11	12.896	1.350	11.7	117
931-1	12.802	1.263	10.9	105
CF068	12.678	1.132	9.8	111
27(896)	12.678	1.132	9.8	117
980-17	12.548	1.002	8.7	121
90-106	12.548	1.002	8.7	108
050	12.286	.740	6.4	120
0317	12.286	.740	6.4	112
862-7	12.050	.504	4.4	105
B076	12.025	.479	4.3	114
861-27	11.894	.348	3.0	114
062-13	11.894	.340	3.0	104
1089V	11.633	.087	3.0	84
802-9	11.633	.087	3.0	108
US 41(ck.)	11.546	--	--	102
1089A	11.502	--	--	102
947-14	11.502	--	--	105
$F_2$067	11.371	--	--	104

Table 2 - Continued

Variety or Line	Acre Yield Tons	Increase Acre Yield over Check (US 41)		Beets per 100 ft. row
		Tons	Percent	Number
980-8	11.371	--	--	96
935	11.243	--	--	102
1000	11.241	--	--	99
035-1	10.849	--	--	93
993-3	10.718	--	--	114
054	10.718	--	--	105
1089	10.587	--	--	81
9229	10.456	--	--	81
050-6	10.456	--	--	108
$F_2$065	10.195	--	--	120
804-2	9.803	--	--	96
056	9.672	--	--	90
M032	8.888	--	--	88
013	8.255	--	--	111

Testing Breeding Material in Crocks.

In addition to testing and selecting sugarbeets in greenhouse and field for nematode resistance, selected lines were also tested in 3-gallon crocks. The crocks were located outside the greenhouse (Figure 3), and the beets were subjected to all the diseases prevalent in the area during the growing season. The crocks were divided into lots of 20 each. Seeds of each line tested were planted and seedlings thinned to a single plant in each crock. Ten crocks contained nematode-infested soil and ten crocks contained nematode-free soil. There were three such replications, or a total of 30 crocks, for each line in nematode-infested and nematode-free soil. To insure uniformity of soil in each crock, all soil used in the test was thoroughly mixed prior to beginning the test. Nematode-infested soil was added to the crocks in which beets were tested for resistance to nematodes. In an equal number of crocks used as checks, no nematode cysts were added. Cultural practices, fertilization, irrigation, etc., were maintained uniform for all crocks. Beets in the crock test were exposed to yellows and mosaic. The beets were not artificially inoculated with the two viruses. Under natural infection, all plants did not acquire the diseases at one time. Plant symptoms were of varying degrees of severity, but it is assumed that beets growing in nematode-infested and nematode-free soil were effected approximately the same, and, therefore, any reduction in yield would be from effect of nematode. The results of this test are presented in Table 3. Loss in weight of roots due to disease varied from 51% in 9229G to 1% in 062-11. Loss in check (US 41) was 23%.

Figure 3. Sugarbeet test for resistance to sugarbeet nematode at the U. S. Agricultural Research Station, Salinas, California. Seeds are planted in 3 gallon crocks in nematode-infested and nematode-free soil.

Table 3. TEST FOR NEMATODE RESISTANCE IN 3-GALLON CROCKS, SALINAS, CALIFORNIA, 1961

Variety	Nematode-Free Soil Av. Wt. Per Beet Grams	Nematode-Infested Soil Av. Wt. Per Beet Grams	Loss Percent
US 41	679.1	523.4	22.9
028	944.5	763.7	19.1
032	707.1	621.9	12.1
033-3	714.2	614.2	14.0
034	742.3	581.3	21.7
050-6	844.2	687.1	18.6
056-1	762.5	676.5	11.3
057-15	850.2	690.5	18.8
062-11	791.0	784.8	.8
075	739.2	589.7	20.2
9229G	807.4	396.4	50.9
1089G	606.2	513.9	15.2

Figure 4. Root system of a sugarbeet showing high incidence of cysts of Heterodera schachtii, indicating high susceptibility to the nematode. (Photo by Charles Price.)

VARIETY TEST UNDER SEVERE NEMATODE EXPOSURE LEWISTON, UTAH, 1961

By C. H. Smith

INTRODUCTION

The evaluation of varieties of sugar beets for nematode resistance in 1961 was conducted on a nematode-infested field located on the Amalgamated Sugar Company farm at the Lewiston, Utah, factory. Lines of sugar beets that had been previously selected for nematode resistance were obtained from U.S.D.A. Research Stations at Salinas, California, and Logan, Utah. Sugar beet lines unselected for nematode resistance were provided from Beltsville and Logan stations.

Careful observations were made of all varieties prior to thinning. Temperatures were high and soil moisture was good for germination, resulting in workable stands in all varieties. Heavy loss of seedlings occurred at thinning, continuing for nearly two weeks after thinning. The heavy seedling loss was determined to be chiefly from black root rather than nematodes alone. Greenhouse tests with cultures of fungus taken from affected beets is expected to give definite proof of the causative organisms. The loss of replications became so great that the field was abandoned August 15.

Discussion of Varieties

The behavior of certain lines tested in previous nematode tests was similar in this test. The basic numbers used as controls, from which standards of classification of the various lines in nematode resistance were based, gave their normal reaction to nematode attacks. Vigor standards were based upon the assumption that the two control numbers used--028 and 211H3--were placed in an intermediate position. In the tables listing the lines tested, vigor rating given is an average of the number of replications remaining in the test at the time of classification. In the August readings stand and uniformity notes were

included to complete the picture of varietal reaction. Averages of readings of the two controls were of replications located in the plot area of the lines considered.

Prior to abandoning the field on August 15, careful examination of the plots revealed that all plants in a Beta patellaris plot were dying. Root examination showed almost complete root deterioration. Plants from another plot were examined and similar deterioration or rot was observed on the larger root tips. Infected tissue was plated on agar and will be cultured and tested on sugar beet seedlings to determine whether it is the same causative organism which previously attacked sugar beet seedlings at thinning. It is believed that the high water table of the beet field aided materially in this root rot development.

VARIETY TEST UNDER SEVERE NEMATODE EXPOSURE
LEWISTON, UTAH, 1961

GROWER: Amalgamated Sugar Company.

SOIL TYPE: Syracuse fine sandy loam.

PREVIOUS CROPS: 1957, sugar beets; 1958, alfalfa; 1959, alfalfa; 1960, sugar beets; 1961, nematode test field.

PLANTED: May 22, 1961.

THINNED: June 20, 1961.

IRRIGATIONS: High water table--irrigated by sprinkling as necessary.

EXPERIMENTAL DESIGN: Each group of sugar beet lines was randomized throughout the experimental area. Effective plot length of 21 feet with 22 inches between rows. Single-row plots used throughout the test. Objective at thinning was 6 to 8 inches. Four-foot alleys separated the ends of each plot. Control plots were planted as strips every twenty rows.

Each group of sugar beet lines appeared together in each replication for convenience of observation. The selected lines were from highly vigorous lines under normal planting conditions.

VARIETY TEST UNDER SEVERE NEMATODE EXPOSURE
LEWISTON, UTAH, 1961

Number	History	Reps planted	July 20, 1961 Vigor	July 20, 1961 Reps	August 8, 1961 Vigor	August 8, 1961 Stand	August 8, 1961 Uniformity	August 8, 1961 Reps
00.1	80.7	6	1.83	5	2.2	3.0	1.9	5
80.7	6317-3 O.P. = 56-408 A.C.	6	2.12	4	2.13	1.5	1.63	4
00.2	83.10 from 56-409 sel.	6	2.5	5	1.5	2.9	1.6	5
90.100	80.8 O.P. = 6318-56409 A.C.	6	1.75	5	1.4	2.1	1.4	5
00.5	80.22 from 55-410 A.C.sel.	6	2.3	5	1.7	2.2	1.5	5
80.19	6320-4 O.P. = 55-410	6	2.0	5	1.7	2.0	1.6	5
028	US 41	1	2.5	1	2.0	3.0	2.5	1
80.20	6320-5 O.P. = 55-410	3	2.0	2	2.0	3.5	2.0	2
80.22	6320-7 R O.P. "	2	2.25	2	1.5	2.5	1.5	1
80.21	6320-6 O.P. "	6	2.13	4	1.25	2.63	1.25	4
90.101	80.17 O.P. = 6320-55-410 A.C.	6	1.9	5	1.37	2.5	1.5	4
028	US 41	6	2.0	4	2.0	1.87	1.4	4
00.6	80.2 from 56-412 A.C. sel.	6	2.5	4	1.3	1.5	1.63	4
80.24	6321-2 O.P.=56-412 A.C.	6	2.5	3	1.0	1.5	1.33	3
90.102	80.23 O.P. = 6321 = 56-412 A.C.	6	2.4	5	1.5	1.8	1.8	5
00.7	9353A from 56-410 A.C. H.Gal.	6	2.1	5	1.4	2.1	1.4	5
00.8	9354A from 56-410 A.C. L.Gal.	6	1.83	3	1.8	2.0	1.8	3
0107	211H3 MM MS X Grp.A. Nem.sel.	6	2.0	3	2.17	2.0	2.0	3
0198	9145 mm MS (SL 129) X Group A, Nem. sel.	6	2.13	4	1.25	2.25	1.5	2
00.100	9353A--from 56-410 A.C. H.Gal.	6	1.83	3	1.25	2.5	1.25	2
80.2	6316-2 O.P. 56-407 A.C.	6	2.5	4	1.25	2.75	1.5	2
90.99	80.1 O.P. 6316 = 56-407 A.C.	6	2.4	5	1.25	2.25	1.75	2
00.9	80.35 from 590-8 P.	6	2.87	4	2.3	2.0	1.5	3
80.36	6351-8 O.P. 590-8 P,US 75	6	3.25	4	2.38	2.6	1.75	4
80.37	6351-9 O.P. 590-8 P	6	2.75	4	2.1	2.5	1.87	4
90.5	80.29 O.P. 6351 = 590-8 P.	6	2.63	4	2.25	3.0	2.0	4
90.105	80.29 O.P. " "	6	2.37	4	1.5	3.0	1.67	3
883	590-8 P.	6	2.5	4	2.1	2.88	1.88	4
00.12	888 from 591-3 P.	6	2.37	4	1.88	2.75	2.1	4
888	591-3 P.	6	2.25	4	2.0	2.67	2.17	3
00.13	892 from 594-1 P.	6	2.3	5	1.67	2.5	1.67	3
892	594-1 P.	6	2.4	5	2.0	2.3	2.0	3
00.10	80.58 from 590-12 P.	6	2.5	4	1.67	2.3	1.67	3
80.56	6353-4 O.P. 590-12 P.	6	2.62	4	1.67	2.3	1.67	3
80.58	6353-6 O.P. 590-12 P.	6	2.13	4	1.3	1.83	1.83	3
90.9	80.57 O.P. = 6353 = 590-12 P.	6	2.37	4	2.0	2.5	1.83	3
90.106	80.57 O.P.	6	2.25	4	1.83	2.3	2.67	3
886	590-12 P. from US 75 sel.	6	2.37	4	1.75	2.25	1.75	4
00.11	80.59 from 590-12 P.	6	2.0	3	1.67	2.17	1.83	3
00.14	854-4 P.	6	2.33	3	2.17	3.17	1.67	3
00.16	853-3 P.	6	2.33	3	1.75	3.5	2.0	2
00.17	8249 mm (747.14 X Misc. mm)	6	2.5	3	1.75	3.5	2.0	2

Number	History	Reps plant-ed	July 20, 1961 Vigor	July 20, 1961 Reps	August 8, 1961 Vigor	August 8, 1961 Stand	August 8, 1961 Uni-formity	August 8, 1961 Reps
00.18	US 22/4 sel.	6	2.0	4	1.5	2.5	1.5	4
92	US 22/4	6	2.33	6	2.25	2.75	1.6	4
0199	9145 mm MS X Nem. sel. (Shaw) (SLC 129)	6	2.3	5	2.17	2.3	1.3	3
0108	211H3 MM MS X Shaw B Grp.	6	2.2	5	2.0	2.3	1.3	3
80.46	6352-5 O.P. from 590-9 P.	6	2.13	4	2.3	2.5	1.5	3
80.47	6352-6 O.P. from 590-9 P.	6	1.87	4	1.88	2.6	1.75	4
80.49	6352-8 O.P. " "	6	2.0	4	1.88	2.12	1.5	4
90.35	80.75 O.P. = 6354 = 592-3 P.	6	1.66	4	1.88	2.5	1.5	4
90.107	80.75 O.P. " "	6	1.63	4	1.88	2.25	1.63	4
90.108	80.78 O.P. " "	6	1.63	4	2.0	2.3	1.67	3
80.79	F_1Mm 747.12 X Nem. res. sel. = 609 X sibs 2 D.	6	2.2	5	1.5	1.75	1.75	2
80.80	F_1Mm 747.14 X Nem. sel. = SLC 117 X 609	6	2.3	5	2.0	2.75	1.5	2
00.15	833-1 P.	6	2.5	5	1.5	2.25	1.5	2
0106	211H3 MM MS X 833-1 P.	6	2.5	5	1.5	2.75	1.5	2
0132	9145 mm MS X 833-1 P.	6	2.5	5	2.0	3.25	1.5	2
0471	F_1Mm 9202 mm X 833-1 P.	6	2.4	5	1.5	3.0	1.5	2
0472	9715 mm X Shaw Nem. sel.	6	2.0	4	1.5	1.75	1.5	2
0473	9202 mm X Shaw Nem. sel.	6	2.25	4	1.5	2.75	1.5	2
0474	9207 mm (SLC 128-0) Shaw Nem. sel.	6	2.0	4	1.5	2.25	1.25	2
028	US 41	6	2.25	4	1.75	2.75	1.75	2
Controls:								
028	US 41	18	2.33	12	2.23	2.55	1.82	11
211H3	112 H3 rr X 111 and 112	18	2.5	11	2.14	3.14	1.68	11

* Key to grading nematode beets

Vigor = 1 to 5
Stand = 1 to 5
Uniformity = 1 to 4

VARIETY TEST UNDER SEVERE NEMATODE EXPOSURE
LEWISTON, UTAH, 1961

Number	History	Reps planted	July 20, 1961 Vigor	Reps	August 8, 1961 Vigor	Stand	Uniformity	Reps
8335	U-I R 161-1957 seed crops SLC 122 MS mm X Sp 571-0	6	1.66	6	1.63	1.75	1.63	4
8336	U-I R 162 SLC 122 MS mm X SP 57102-0	6	1.83	6	2.0	1.75	1.75	4
880	590-3 P. Sel. US 75	6	1.83	6	2.0	2.17	2.0	3
881	590-5 P. Sel. "	6	1.75	6	1.83	1.83	1.3	3
882	590-6 P. Sel. "	6	1.75	6	1.88	1.88	1.88	4
884	590-9 P. Sel. "	6	2.08	6	2.0	2.37	1.88	4
885	590-11 P. Sel. "	6	2.0	6	1.88	1.88	1.5	4
887	591-2 P.	6	1.75	6	1.88	2.0	1.88	4
889	592-1 P. US 33 sel.	6	2.08	6	2.25	2.88	1.75	4
890	592-2 P.	6	2.0	6	1.88	1.75	1.62	4
891	592-3 P.	6	1.66	6	1.88	1.5	1.37	4
893	594-2 P.	6	1.66	6	1.5	1.5	1.37	4
894	F_1 7267 X 590-3 etc.	6	1.25	6	1.17	1.3	1.17	3
9351A	58-418 Low Gal. sel from 56-408 A.C.	6	1.58	6	1.16	1.67	1.16	3
9352A	58-419 " "	6	1.5	6	1.12	1.62	1.5	4
9353A	58-604 High Gal. sel. from 56-410 A.C.	6	1.5	6	1.4	1.6	1.6	5
5354A	58-605 Low Gal. sel. from 56-410 A.C.	6	1.25	6	1.4	1.7	1.7	5
9355A	56-407 Low Gal. sel. from 56-413 A.C	6	1.58	6	1.4	1.6	1.5	5
9356A	SLC 117 X 56-407-0 X (610 X 91) 108 X 117 MS) X 56-407-0	6	1.58	6	1.2	1.4	1.3	5
028	US 41	3	1.83	3	1.25	1.25	1.75	2
0913	<u>Beta patellaris</u> (1950 seed)	3	1.0	2	1.0	1.0	1.0	2
6051-0	Lines from G. E. Coe, 1961	4	1.5	4	1.5	1.5	2.0	1
60103-01		4	1.75	4	1.5	2.0	2.0	1
60104-01		4	1.5	4	1.25	1.0	1.25	2
60105-01		4	1.87	4	1.75	1.5	2.0	2
60106-01		4	1.63	4	1.5	1.25	1.5	2
60107-01		4	1.75	4	1.5	1.25	1.25	2
60108-01		4	1.5	4	1.25	1.0	1.75	2
60109-01		4	1.37	4	1.25	1.25	1.75	2
60110-01		4	1.5	4	1.75	1.25	1.25	2
60111-01		4	1.13	4	1.67	1.17	1.67	2
60112-01		4	1.87	4	2.0	1.5	2.0	3
60113-01		4	1.87	4	2.17	1.67	2.17	3
60114-01		4	1.87	4	2.0	1.67	1.83	3
60115-01		4	1.75	4	2.5	1.67	2.0	3
60116-01		4	1.75	4	2.5	1.17	1.67	3
60117-01		4	1.75	4	2.17	1.83	1.83	3
60118-01		4	1.75	4	2.17	1.83	2.0	3
60119-01		4	1.63	4	1.83	1.83	2.0	3
60120-01		4	1.87	4	1.5	1.75	1.5	3
60121-01		4	1.87	4	1.67	1.67	1,67	3

VARIETY TEST UNDER SEVERE NEMATODE EXPOSURE
LEWISTON, UTAH, 1961

Number	History	Reps planted[1]	July 20, 1961 Vigor	July 20, 1961 Reps	August 8, 1961 Vigor	August 8, 1961 Stand	August 8, 1961 Uniformity	August 8, 1961 Reps
	Lines from Charles Price							
A050-6	1961	6	2.33	6	2.17	1.67	1.67	3
C 068		6	1.75	6	2.25	2.0	1.75	2
CF 068		6	1.83	6	2.17	2.17	2.0	3
MO-74		6	1.58	6	1.67	1.67	1.5	3
1089		6	2.08	6	1.87	1.75	1.35	4
B 076		6	1.5	6	1.5	1.75	1.25	4
075		6	1.5	6	1.75	1.87	1.75	4
054		6	1.75	6	1.67	1.36	1.67	3
056-1		6	1.58	6	1.83	1.33	1.33	3
0317		6	1.75	6	2.0	1.5	1.5	3
057-15		6	1.75	6	1.7	1.8	1.4	5
060		6	1.75	6	1.9	1.9	1.9	5
033		6	1.33	6	1.7	1.7	1.4	5
032		6	1.67	6	1.9	1.9	1.8	5
SL 060-3		6	1.5	6	1.4	1.7	1.5	5
SL 062-13		6	1.5	6	1.75	1.83	1.41	6
SL 054-1		6	1.17	6	1.67	1.3	1.5	6
M 032		6	1.83	6	1.5	1.7	1.4	5
034		6	1.58	6	1.4	1.4	1.6	5
060-3		6	1.5	6	2.2	1.8	2.0	5
C 050-6		6	1.75	6	2.67	2.67	1.67	3
C 034		6	1.83	6	2.67	3.3	1.5	3
C 094-2		6	1.5	5	1.25	1.62	1.37	4
SL 062-15		6	1.5	6	1.37	1.5	1.5	4
1089-A		6	2.08	6	1.87	2.5	1.75	4
9122A	F_1Mm 7121 mm X CT5 rr	8	1.81	8	1.8	1.8	1.8	5
9140	7121 MS mm X 803 of CT5 MM	8	1.63	8	2.0	1.6	1.8	5
0110	211H3 MM MS X 924 etc. (CT5 mm)	8	1.75	8	1.8	1.3	1.7	5
0179	9132 rr mm MS X 924 etc.	8	1.94	8	2.0	1.6	1.6	5
0462	7864 of CT8 X 5080 (line 289 ++)	8	1.88	8	1.8	1.6	1.4	5
E 67	CT9 MS X Amalgamated mm	8	1.75	8	2.0	1.8	1.2	5
0457	630 X 94.55 of CT5	8	1.94	8	1.9	1.8	1.3	5
0539	95.267.3 rr mm ++ O.P.	8	2.13	8	2.1	1.8	1.6	5
0464	431+5 X 5080	6	1.75	6	1.5	1.75	1.37	4
8210	7207 X 7725 mm	6	1.93	6	2.0	1.5	1.12	4
9450	803 aa of CT5 X sibs +a	8	2.08	6	2.2	2.0	1.7	5
9451A	84.54 aa of CT5 X sibs	8	2.58	6	2.6	1.8	1.7	5
9051	84.54 of CT5, sib O.P.	8	3.07	7	2.7	2.0	1.5	5
9052	84.55 of CT5, O.P.	8	3.0	8	2.7	2.2	1.7	5
Controls:								
028	US 41	24	1.74	23	1.76	1.71	1.65	17
211H3	112H3 rr X 111 and 112	24	1.94	24	1.75	1.69	1.78	16

* Key to grading nematode beets   Vigor = 1 to 5, Stand 1 to 5, Uniformity 1 to 4

PART X

CURLY TOP INVESTIGATIONS

- - -

VIRUS YELLOWS INVESTIGATIONS

and

BREEDING FOR YELLOWS RESISTANCE

Foundation Project 12

C. W. Bennett
J. E. Duffus
J. M. Fife
J. S. McFarlane
I. O. Skoyen

Investigations supported in part by funds received from California Beet Growers Association, Limited, under Cooperative Agreement.

ISOLATION OF HIGHLY VIRULENT STRAINS OF CURLY TOP VIRUS FROM BEETS IN WESTERN UNITED STATES

C. W. Bennett

Introduction

It has been known for more than 30 years that beet curly top virus is a complex of strains that vary in virulence, induced symptoms, host range, and perhaps other characteristics. Giddings (2,3,5) described 12 strains of this virus. One strain obtained from Idaho was highly virulent on sugar beet and was designated "Strain 11" (5). This strain is capable of causing marked injury even on resistant varieties of sugar beet.

During the season of 1960 curly top caused considerable damage to individual plants in some fields in central San Joaquin Valley, but no special study was made of strains of the virus involved. In 1961 curly top symptoms were so severe on plants in certain fields near Shandon, Los Banos, and Tracy that it was thought advisable to compare the degree of virulence of the virus strains involved with that of strains previously isolated. Results of these tests are presented in this report.

Materials and Methods

Beet plants affected with curly top were selected from fields near Shandon, Los Banos, and Tracy, and planted in pots at the U. S. Agricultural Experiment Station at Salinas, California. Also, beets received from

Wyoming and from Colorado were potted and included in the tests. After sufficient top growth was produced on the potted beets, nonviruliferous beet leafhoppers were allowed to feed on the diseased plants 3 days, or more, and then caged singly on seedling sugar beet plants. To determine the relative virulence of virus from different field beets, tests were made using the susceptible selection SL 742, the resistant variety US 75, and the very resistant selection SL 68. Additional tests and subtransfers were made on US 75 and on hybrid varieties with high degrees of resistance.

Only plants with very severe symptoms were selected from fields in California. Therefore, the virus recovered from these plants probably represents strains of virus of the highest virulence to be found in the respective fields and the results are not necessarily representative of the fields as a whole.

Results were compared with those obtained with strain 11 on the different varieties and selections used in testing the field beets. Strain 11 was chosen because it is the most virulent of the curly top virus strains described to the present time. This strain was tested at Jerome, Idaho, in 1956 and 1957, on four varieties of beets growing in field plots (7). In both years, strain 11 caused substantially greater losses on all varieties than was caused by natural infection. This was true even in 1957 when plots naturally infected yielded only 2.47 to 5.20 tons per acre.

Severity of injury on the test plants by virus from different field plants was estimated on the basis of stunting, leaf curling, and plant survival. A numerical grading system, ranging in ascending order of severity from 1 to 5, inclusive, was used in estimating relative virulence of virus from the different sources.

Results

The results of tests of representative beets from different areas are shown in Table 1. As would be expected, a range of severity of symptoms was produced by virus from different sources. Highly virulent strains were obtained from beets from Shandon, Los Banos, Tracy, and Wyoming. Some of these were obviously more virulent than strain 11 with which they were compared. The relative amounts of dwarfing by a strain of virus from Shandon and by strain 11 on a hybrid variety (1 X 3) and on US 75 are shown in Figure 1. Several other isolates appeared also to be more virulent than strain 11 when tested on US 75 (Table 1).

Transfers from some of the field beets gave uniformly severe effects. Transfers from others gave a range of severity of symptoms on US 75, indicating that the plants were infected with a mixture of strains. Subtransfers from mildly affected test plants gave predominantly mild symptoms; whereas transfers from severely affected plants gave severe symptoms only, or a range of severity of symptoms, indicating that more than one strain of virus had been transmitted. These results supply further evidence that field beets often are infected with a mixture of curly top-virus strains.

Table 1. Relative virulence of curly top virus strain 11 and isolates from beets from different areas of western United States, as indicated by tests on the variety US 75.

Source of beet tested	Number[1/] of plants showing indicated grade of severity					
	1	2	3	4	5	Average Severity
Shandon	0	0	2	9	7	4.3
Shandon	0	3	6	7	2	3.4
Shandon	3	2	5	2	4	3.1
Shandon	0	0	0	3	11	4.8
Shandon	0	0	0	10	7	4.4
Shandon	0	0	0	7	7	4.5
Shandon	0	1	1	5	11	4.4
Tracy	0	0	0	0	11	5.0
Tracy	0	0	1	3	13	4.7
Tracy	0	2	5	5	0	3.2
Los Banos	0	0	0	1	11	4.9
Los Banos	0	0	0	1	12	4.9
Los Banos	0	0	1	8	9	4.4
Wasco	0	2	12	0	0	2.8
Wyoming	0	2	14	0	0	2.9
Wyoming	0	1	1	3	13	4.6
Wyoming	0	6	10	0	0	2.6
Strain 11	0	0	6	11	2	3.8
Strain 11	0	0	2	9	4	4.1
Strain 11	0	0	5	10	2	3.8

1/ Twenty plants were inoculated in each test.

Fig. 1. Sugarbeet plants showing the effects of a Shandon (S) curly top virus isolate and strain 11 on 1 X 3 (top) and US 75 (bottom).

Giddings (4) showed that a single beet leafhopper is able to carry a combination of at least three strains of virus. When such leafhoppers were allowed short feeding periods on seedling beets, they introduced the strains into the plants singly and in all possible combinations. The beet leafhopper, therefore, may infect beets with more than one strain of virus in a single feeding. Also, plants infected with one strain remain susceptible to infection by other strains. If the second strains is more virulent than the strain already present, symptoms of curly top are increased by the second strain.

Four of the more virulent isolates--one from Shandon, two from Los Banos, and one from Wyoming--were selected with which to make a series of transfers to different varieties and selections of sugar beets and other plants. These isolates have continued to produce very severe symptoms on resistant varieties and selections such as US 75 and SL 68. Infected plants of US 75 produced curled and dwarfed leaves, and little growth was produced after the plants showed first symptoms of disease. High percentages of plants inoculated in the cotyledon stage with the four virus selections were killed. The virus isolates have maintained their relative degrees of virulence, as compared to strain 11, through three or more transfers on US 75. Each of these four isolates has appeared to be more virulent than strain 11 on sugar beet.

Damage by Virulent Strains of Virus

It is not possible to accurately assess the damage produced in 1961 by virulent strains of curly top virus in any specific area, because injury varied in different fields depending on the time of infection,

vigor of plants, and other factors. It was evident, however, that in certain fields yields were greatly reduced.

In the Shandon and Los Banos areas, beet leafhoppers moved into the beet fields a month to six weeks earlier than normal, owing to the earlier drying of desert vegetation which forced the leafhoppers to migrate. In certain areas, also, there was overwintering of leafhoppers on the floor of the valleys; close to beet fields in some instances. In some fields leafhoppers were present at thinning time. Where conditions were unfavorable for very rapid growth, leafhoppers multiplied in the beet fields and produced high percentages of infection. In some fields the leafhoppers continued to multiply through the summer. Fields were found near Los Banos and Shandon that had fifty or more leafhoppers per plant in June and July. Plants in these fields did not attain sufficient size for the foliage to cover the rows. Thus, they were exposed to direct sunlight throughout the summer and remained favorable hosts for multiplication of leafhoppers.

The high summer populations of leafhoppers probably account for the severe damage noted in some fields. The leafhoppers that initially invaded the beet fields from the desert areas undoubtedly carried many different strains of curly top virus ranging in virulence from mild to very severe. Tests over a period of years have indicated that leafhoppers from desert areas predominantly carry mild strains of virus. Giddings (6) suggested that this is due to the fact that virulent strains of virus kill most desert host plants. If this is true, virulent strains of virus that may be developed in the natural breeding grounds of the beet leafhopper tend to be self eliminating.

After virus is carried from the desert breeding grounds to beet fields by the beet leafhopper, factors involved in strain selection change radically. In beets it is the highly virulent strains of virus that are best equipped to survive.

The sugar beet plant is an excellent host for increase of the beet leafhopper if plants are small and exposed to full sunlight. If the plants are large and the foliage covers the rows so that conditions of shade and high humidity prevail, little leafhopper increase occurs. Virulent strains of virus, by stunting the beet plants, provide more favorable conditions for leafhopper increase. Also, since strains of curly top virus do not afford cross-protection against each other, plants infected with a mild strain of virus remain susceptible to infection with more virulent strains. Where high populations of leafhoppers are present in a field they may continue to spread more virulent strains throughout the season. The disease, therefore, may become progressively more severe as the season advances. By the end of the season, most of the plants may be infected with the most virulent strains of virus along with any less virulent strains that may be present.

Evidence of progressive spread of more virulent strains of curly top virus in fields already 100 percent infected was noted in beet fields near Los Banos as late as November 2. Many of the plants observed showed mild vein swelling on the older leaves, indicating that they had first been infected with a mild strain of virus. On November 2, some of these plants had young leaves that were badly curled, indicating that the plants had been reinfected with a more virulent virus strain.

As already stated, the strain complex in desert areas apparently has remained more or less stable over a period of many years. No new factors are known to have been introduced that would change this condition. However, if conditions should arise which would permit perpetuation of virus on beets through the year, the percentage of beet plants infected with the more virulent strains would be expected to increase.

Conclusions

The results of tests of virus isolates from field beets in 1961 indicate that strains of the curly top virus, capable of causing appreciable damage to resistant varieties of sugar beets, were present in widely separated areas of western United States. The findings emphasize the desirability of maintaining and increasing the curly top resistance of all new varieties that are developed for use in areas of western United States where curly top virus and the beet leafhopper are prevalent.

Literature Cited

(1) Bennett, C. W. 1957. Interaction of sugar-beet curly top virus and an unusual mutant. Virology 3: 322-342.

(2) Giddings, N. J. 1938. Studies of selected strains of curly top virus. J. Agr. Res. 56: 883-894.

(3) Giddings, N. J. 1944. Additional strains of the sugar-beet curly top virus. J. Agr. Res. 69: 149-157.

(4) Giddings, N. J. 1950. Combination and separation of curly-top virus strains. Proc. Am. Soc. Sugar Beet Technol. 6: 502-507.

(5) Giddings, N. J. 1954. Two recently isolated strains of curly top virus. Phytopathology 44: 123-125.

(6) Giddings, N. J. 1959. The stability of sugar beet curly-top virus strains. J. Am. Soc. Sugar Beet Technol. 10: 359-363.

(7) Murphy, Albert M., C. W. Bennett, and F. V. Owen. 1959. Varietal reaction of sugar beets to curly top virus strain 11 under field conditions. J. Am. Soc. Sugar Beet Technol. 10: 281-282.

INCIDENCE OF BEET VIRUS DISEASES IN RELATION TO OVERWINTERING BEET FIELDS

James E. Duffus

SUMMARY

Overwintering sugar beets serve as important reservoirs of several beet virus diseases. The occurrence of such fields adjacent to or very near young plantings can be partially responsible for serious losses in the plantings. If overwintering cannot be avoided, new plantings should be made as far away as possible from such sources.

INTRODUCTION.--European reports (3,5) have indicated a close correlation between beet yellows virus incidence and overwintering beet fields. Bennett (1) has indicated that the principal source of beet yellows infection of new beet plantings in the U. S. appears to be the beet itself. In Europe the sources include beet seed crops and clamps containing infected mangolds; in the United States, they include escaped beets growing in waste places and overwintering beet fields.

Beet mosaic virus, in Europe, has been shown to be even more closely associated with overwintering fields than the beet yellows virus (5).

The beet western yellows virus has been isolated from beet fields in high incidence during all times of the year (4), and when beets are present they serve as an important source of the virus, although a number of other crop and weed hosts also serve as important virus sources.

Early during the 1958 growing season C. W. Bennett brought to the author's attention the possibility of studying the spread of yellows and

mosaic in the Five Points area of California in relation to an observed virus source, an overwintered beet field. The results of these observations are reported here.

METHODS.--Extensive surveys in a 126 square mile area surrounding Five Points, California, were carried out in an effort to map all beet fields in the area and to establish the occurrence of sources of virus which could subsequently affect the crop.

The incidence of yellows (beet and western) and mosaic was assessed by counting plants in the fields at 2-week intervals during 1958 and at monthly intervals during 1959. The number of plants showing symptoms of the various diseases was counted in 10 to 20 samples (depending upon size of field) of 100 plants situated at equal intervals along diagonals of the fields.

RESULTS.--Surveys in 1958 indicated that the major source of virus for the entire area was an overwintered, 160-acre, beet field. Scattered weeds in the Cruciferae and Compositae, especially along irrigation canals, probably served as additional sources of the western yellows virus. Surveys during the winter of 1958-1959 indicated no overwintered beet fields in the area, but again numerous scattered weeds in the families Cruciferae and Compositae showed symptoms of western yellows.

Figures 1 and 2 show the incidence of beet mosaic and yellows-complex viruses in 6 representative fields during both growing seasons. The field adjacent to the overwintered virus source in the 1958 growing season (A) had extremely high virus incidence early in the season. The plants were essentially 100 percent infected with yellows and mosaic by May 15. Fields varying distances from the source field showed marked

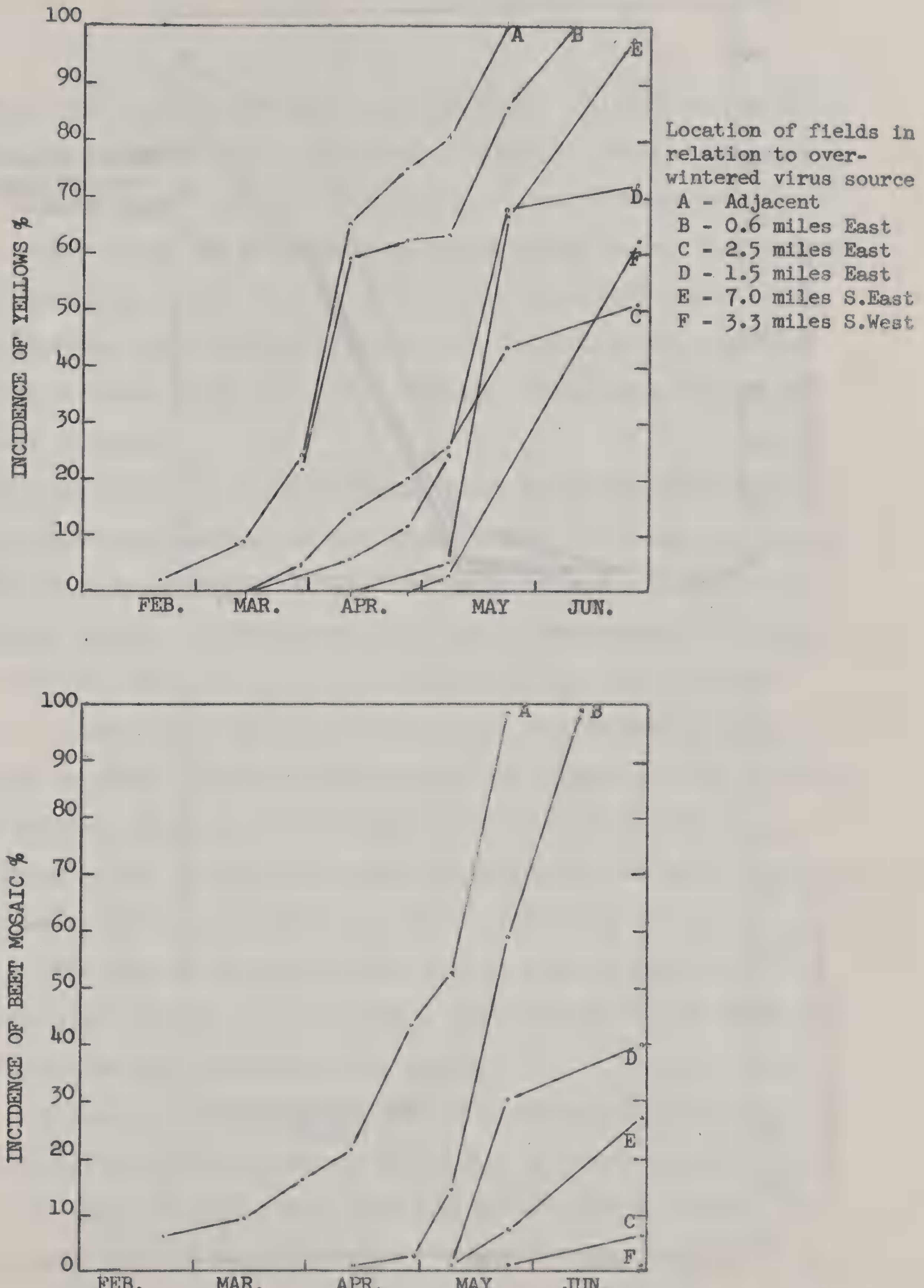


Figure 1.--Virus incidence - Five Points, California, 1958.

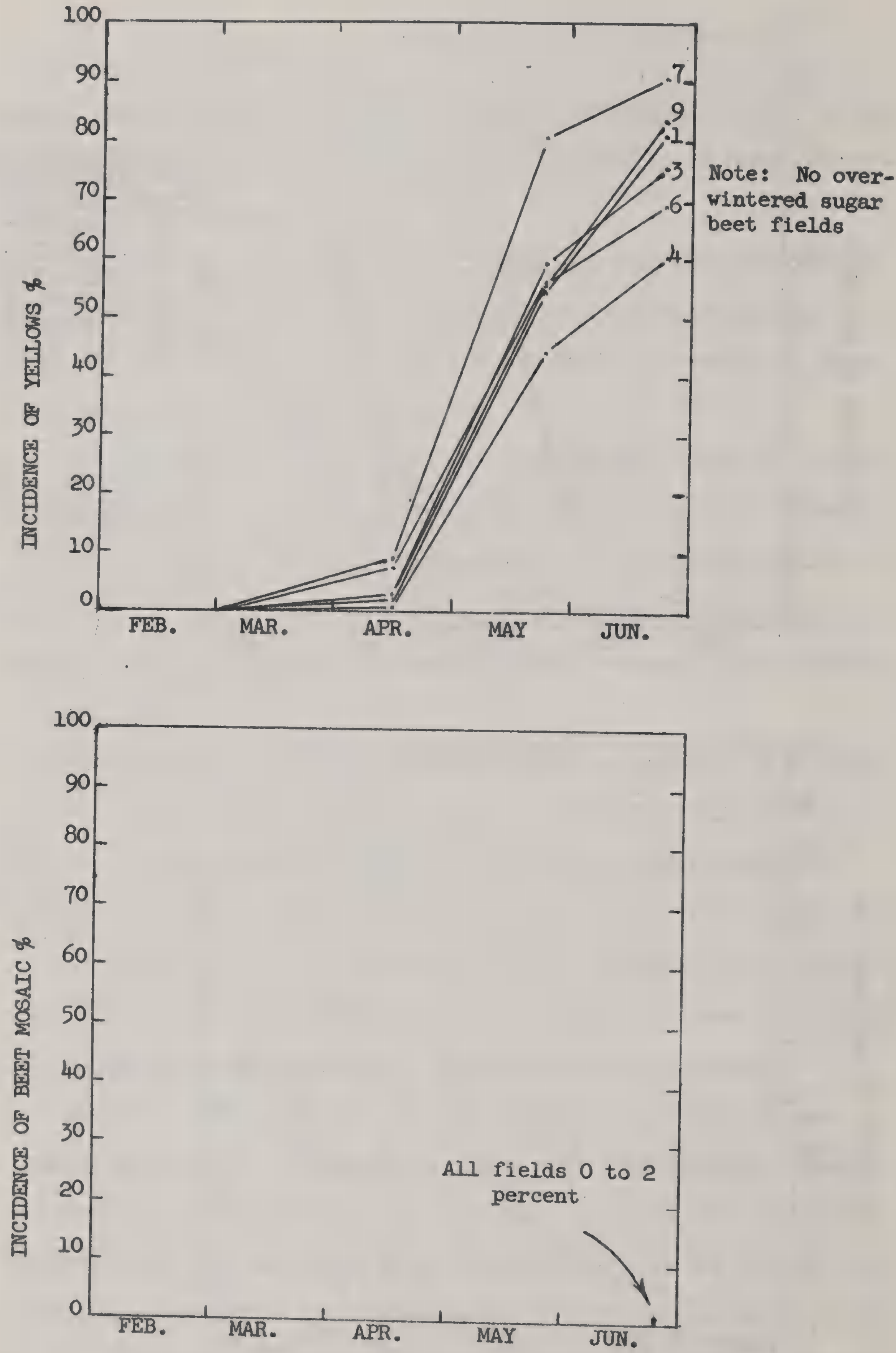


Figure 2.--Virus incidence - Five Points, California, 1959.

reductions in amount and earliness of infection. This was especially true for the occurrence of beet mosaic. Fields 1.5 miles or more away from the overwintered source had infection curves which are probably representative of the area when such sources do not occur. They compare favorably with infection curves obtained during the 1959 season. The overwintered field, however, probably contributed to a higher general level of mosaic in the area during 1958 and probably also added to the level of yellows.

The elimination of overwintering fields during 1959 practically eliminated the importance of beet mosaic to the crop during this season. The curves of yellows incidence showed an important lag in build-up and are probably representative of the area in years when overwintering is not practiced.

Evidence is accumulating that indicates that the western yellows virus is endemic in western growing areas and probably a large percentage of yellows infections in fields away from previous beet crops are induced by this virus. Beet yellows and beet mosaic are more epiphytotic in nature and depend upon the presence of overwintered beets.

Data from the infection curves, Figures 1 and 2, when used to express the possible damage induced by these viruses in sugar yield show clearly the importance of early infection.

Watson et al. (7) have shown with beet yellows that the loss of yield due to infection appearing at any time was approximately proportional to the interval between that time and the date of harvest. They indicated that the loss caused by the disease on artificially infected beets was 4 - 5 percent of the sugar yields for every week during which

the plants show symptoms until harvested. Work in the U. S. (2,4) has indicated that these figures may be high for the virus isolates that occur here and that probable loss is approximately 1 - 2 percent per week. In calculating damage caused by mixed infections of beet and western yellows viruses the figure 1.7 percent loss per week was used, a figure obtained in experimental plots with mixed infections of the 2 viruses.

Little is known of the loss induced by infections of the beet mosaic virus. Watson et al. (6) in replicated plots have shown, however, reductions of 10 - 20 percent in sugar yield in plants infected for 16 weeks, or approximately 1 percent loss per week. Half that loss (0.5 percent) was assumed for our conditions.

The calculated loss using these factors for the various fields is found in Table 1. These figures indicate that the fields near the over-wintered virus source had approximately twice the loss of sugar per acre induced by these viruses as the fields 1.5 miles or further away from the source. The average percentage loss for the fields 1.5 miles or further away from the source in 1958 is essentially the same as the virus induced loss in 1959.

Table 2 shows the actual yields of blocks of fields in this area, for the 1958 and 1959 growing seasons, supplied by J. Veihmeyer, Holly Sugar Corporation. Although direct comparisons cannot be made because individual field yields were not available, the marked reduction in sugar yield in the block that contained both fields near the virus source as compared to the other fields in the area is readily apparent.

Table 1.--Calculated percentage loss of gross sugar caused by yellows and beet mosaic, Five Points, California 1958, 1959.

Field	Calculated percentage loss in gross sugar	Location of field in relation to over-wintering virus source
A - 1958	40.8[a]	Adjacent
B	36.7	0.6 miles East
C	16.3	2.5 miles East
D	20.7	1.5 miles East
E	23.3	7.0 miles S. East
F	9.91	3.3 miles S. West
All - 1959	17.41	No overwintered fields

[a] Assuming 1.7% loss for each week infected with yellows and 0.5% loss for each week infected with mosaic.

Table 2.--Actual yield and sucrose content of sugar beets, Five Points, California, 1958, 1959.[a]

Fields[b]	Sucrose (%)	Yield of beets /A (T)	Gross sugar /A (lb)
A, B, F - 1958	13.83	11.0	3042
C, D, E - 1958	13.0	18.7	4862
All - 1959	14.9	14.4	4290

[a] Yields supplied by J. Veihmeyer, Holly Sugar Corporation.

[b] Individual field data not available; A.-adjacent to source, B.-0.6 miles East, C.-2.5 miles East, D.-1.5 miles East, E.-7.0 miles S. East, F.-3.3 miles S. West, all fields 1959 - no overwintered fields.

Overwintering sugar beets serve as important reservoirs of several beet virus diseases. The occurrence of such fields adjacent or very near young plantings can be partially responsible for serious losses in the young plantings. It would seem advisable that if overwintering cannot be avoided that new plantings be made as far away as possible from such sources.

LITERATURE CITED

1. Bennett, C. W. 1959. Sugar beet yellows disease in the United States. U. S. Dept. Agr. Tech. Bull. 1218, 63 p.

2. Bennett, C. W., C. Price, and J. S. McFarlane. 1957. Effects of virus yellows on sugar beet with a consideration of some of the factors involved in changes produced by the disease. Am. Soc. Sugar Beet Technol. J. 9: 479-494.

3. Broadbent, L., C. E. Cornford, R. Hull, and T. W. Tinsley. 1949. Overwintering of aphids, especially Myzus persicae (Sulzer), in root clamps. Ann. Appl. Biol. 36: 513-524.

4. Duffus, J. E. 1961. Economic significance of beet western yellows (radish yellows) on sugar beet. Phytopathology 51: 605-607.

5. Watson, Marion A., R. Hull, J. W. Blencowe and Brenda M. G. Hamlyn. 1951. The spread of beet yellows and beet mosaic viruses in the sugar-beet root crop. I. Field observations on the virus diseases of sugar beet and their vectors Myzus persicae Sulz. and Aphis fabae Koch. Ann. Appl. Biol. 38: 743-764.

6. Watson, D. J. and Marion A. Watson. 1953. Comparative physiological studies on the growth of field crops. III. The effect of infection with beet yellows and beet mosaic viruses on the growth and yield of the sugar-beet root crop. Ann. Appl. Biol. 40: 1-37.

7. Watson, Marion A., D. J. Watson, and R. Hull. 1946. Factors affecting the loss of yield of sugar beet caused by beet yellows virus. I. Rate and date of infection; date of sowing and harvesting. J. Agr. Sci. 36: 151-166.

BREEDING FOR RESISTANCE TO VIRUS YELLOWS ON THE BASIS OF A SUPERIOR ROOT WEIGHT AND ON THE BASIS OF A SUPERIOR AMINO ACID RATIO IN THE MATURE LEAVES OF YELLOWS-INFECTED PLANTS

BY

J. M. Fife

SUMMARY OF ACCOMPLISHMENTS

Sugarbeet selections, made on the basis of a superior amino acid ratio in the mature leaves of yellows-infected plants and on a superior root weight from yellows-infected plants, of variety US 75, were tested in the greenhouse and under field conditions for resistance to virus yellows. Tests were also conducted in the greenhouse to determine the amount of resistance these selections have to curly top.

Five selections were tested in the field with the parent, using a 6 by 6 latin square plot arrangement and under severe yellows conditions. Three selections were superior to the parent in gross sugar per acre. Two of the five selections were superior to the parent in yield of beets per acre, while two selections were superior to the parent in the percentage sucrose in the roots. The growth rate of young plants, under both healthy and yellows conditions, appears to be a reliable method of identifying selections having resistance to virus yellows and selections which have greater vigor under healthy conditions.

Certain sugarbeet selections, made for resistance to virus yellows, were tested for resistance to curly top in the greenhouse. Of the 8 selections tested, 3 selections showed greater curly top resistance than the curly top-resistant parent US 75. Three selections were equal

in resistance to the parent, while 2 selections were more susceptible to curly top than the parent.

Three selections were made for resistance to virus yellows on the basis of a superior concentration of two amino acids and a superior amino acid ratio in the mature leaves of healthy plants of curly-top-resistant variety US 75. These three selections were not resistant to virus yellows, as expected, but were highly susceptible to curly top. These selections were found to be as susceptible to curly top as one of the most susceptible selections known; that is,742. It appears that resistance to curly top may be associated with aspartic acid and glutamic acid metabolism in the plant and that susceptibility to curly top may be obtained by selection from healthy plants. These studies indicate that curly top resistance may be retained, or may even be increased while breeding for resistance to virus yellows.

INTRODUCTION

Twenty-eight plants, having a superior root weight and an amino acid ratio, $\frac{\text{aspartic acid + glutamic acid}}{\text{citrulline + alanine}}$, greater than the mean in the mature leaves of inoculated plants, were selected from more than 1000 plants tested. These 28 plants made up a polycross for seed increase. The seed from each plant was kept separately, thereby making each selection originating from a single plant progeny. Ten other plants, having a superior amino acid ratio and a greater than the mean root weight, made up a polycross for seed increase. The seed from each of these plants was also kept separate,thus making each of the 10 selections originating from a single plant progeny.

This report presents screening tests which were conducted in the greenhouse and in the field to indicate which selections may be superior to the parent under extreme yellows conditions and suitable for further extensive field trials. Some of these selections were also tested for curly top resistance.

PERFORMANCE TEST OF SELECTIONS UNDER SEVERE YELLOWS CONDITIONS IN THE FIELD

Five selections, which appeared to show promise, of having resistance to yellows, were tested under severe yellows conditions in the field during the past season. This test was conducted in a section of the experimental plot along with the regular April 18 planting of the variety test for yellows resistance conducted by McFarlane, Bennett, and Skoyen. The agronomic operations were the same for the entire plot, the only difference being the experimental design. The information pertinent to this test is given below.

Location: Spence Field, on a sandy loam.

Fertilizer Used: 375 lbs. Per acre 10-10-5 preplant.
260 lbs. Per acre, Sidedress, June 20.

Thinned: May 24. Harvest date: September 25. Plots: 30 feet long.

Disease: Inoculated with a virulent strain of yellows virus May 29.

Irrigations: At 7- to 10-day intervals with sprinkler.

Insects: Plot sprayed to control aphid and leaf miner.

Experimental design: 6 by 6 latin square, single row plots, rows spaced 28 inches apart.

Sugar analysis: From two 20-beet samples per plot.

Due to the very small amount of seed available, a single seed was hand planted at 7-inch intervals. After thinning, small plants were transplanted in the few spaces where the seed failed to germinate, thus making a perfect stand during the growing season. At harvest, the transplanted plants were discarded leaving 89 percent of a perfect stand for yield and sucrose determinations. The yield of each plot was corrected for stand. The results of this test are shown in table 1.

Using Duncan's multiple range test, it was shown that the values having a superscript "a" are superior to the parent at the 5-percent level.

From this test, it appears that two selections may produce a significantly greater yield of roots than the parent, while two other selections appear to have a significantly higher sucrose content. Three of the five selections tested produced a significantly greater gross sugar-per-acre yield than the parent.

PERCENTAGE SUCROSE IN COMMERCIALLY GROWN ROOTS

OF SELECTIONS MADE FOR RESISTANCE TO YELLOWS

In view of the very small amount of seed obtained from single plant progenies, it was necessary to make seed increases of the selections before extensive evaluation tests could be conducted. Through the courtesy of a grower, it was possible to grow roots to maturity in a commercial field for a test on the percentage of sucrose and then save roots of the selections for seed increase.

The commercial field was planted on two-row beds on December 21, 1960. The seed of the parent (US 75) and the commercial variety was drilled on the same bed for the length of the plot. Two such beds were

Table 1.

Field test of selections made under severe yellows conditions

Selection	Basis Upon Which Selection Was Made	Acre Yield Sugar	Acre Yield Beets	Sucrose
	A Superior	Pounds	Tons	Percent
US 75	Parent	4702	15.0	16.0
91DS-9	Root Weight	6255[a]	20.0[a]	15.7
91DS-22	Root Weight	6355[a]	19.7[a]	15.0
91DS-23	Root Weight	6104[a]	17.9	17.1[a]
91DS-24	Root Weight	5619	16.9	16.5
101RS-5	Root Weight And Amino Acid Ratio	4072	12.7	17.1[a]
General MEAN of all selections		5529	17.0	16.4
S. E. of MEAN		420	1.40	0.29
Significant Difference (19:1)		1223	4.1	0.83
S. E. of MEAN in % of MEAN		7.6	8.2	1.8

Odds 19:1 = 2.060 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar Tons	Pounds Per Plot	Sucrose Percent
Between Selections	5	1.2732	465.08	2.03
Between Replications	5	0.0367	27.12	0.27
Remainder (Error)	25	0.2650	114.83	0.49
Total	35			
Calculated F Values		4.80**	4.05**	4.12**

Superscript "a": Superior to the parent at the 5-percent level

** Exceeds the 1% point of significance (F=3.86)

planted. On two adjacent beds, the commercial variety was drilled on one side of each bed. Single seeds of each selection were planted by hand, using an 8-inch spacing, in the remaining row of the two beds. The plots were 34 feet long. The parent and the commercial variety were thinned to 8 inches. The few vacant spaces, caused by the failure of the seed of the selections to germinate, were filled with transplants of similar size at thinning to insure uniform competition during the growing season.

The entire field showed a uniform virus-induced yellowing. The yellowing symptoms appeared milder on certain of the selections than the symptoms on the parent or the commercial variety. At harvest the roots of the transplanted plants were discarded leaving an average stand for the selections of approximately 90 percent. The roots in one row of the selections were dug and trimmed for seed. The roots of the selection in the row used for sucrose test were harvested on October 9. The roots were topped and two 20-beet samples saved from each selection. The sucrose content of the roots of the parent and of the commercial variety was determined on two 20-beet samples taken from each block in the plot. The mean percentage sucrose of the selections tested, together with the sucrose content of the parent and the commercial variety, is shown in table 2.

Of the 15 selections tested, only 4 showed a sucrose content below 13.0 percent, while the roots of the parent in only 5 blocks, of the 15 tests made, had a sucrose content of 13.0 percent or above. The sucrose content of the commercial variety did not reach 13.0 percent in any of the 15 tests made.

Table 2.

Sucrose percentages in roots of selections made for resistance to virus yellows when grown under commercial conditions

Block	Selection And Basis Upon Which Selection Was Made	Sucrose	Variety US 75 Sucrose	Variety Spreckels #1 Sucrose
		%	%	%
Superior root Wt. & greater than mean amino acid ratio				
1	91DS-3	13.7	12.8	12.2
2	91DS-9	13.3	13.3	11.6
3	91DS-22	13.1	13.0	10.9
4	91DS-23	15.0	12.2	12.7
6	91DS-24	14.6	12.0	12.3
8	202S-3	13.5	12.9	12.8
9	202S-23	12.9	12.5	12.5
	Mean	13.7	12.7	12.1
Superior amino acid ratio & greater than mean root Wt.				
5	91DR-6	14.0	14.4	12.9
10	302R-3	11.7	11.3	11.3
11	302R-6	12.2	12.4	10.6
12	302R-13	11.6	11.1	10.6
	Mean	12.4	12.3	11.4
Superior amino acid ratio & a superior root weight 1/				
7	101RS-1	13.3	13.2	11.9
13	101RS-4	14.4	14.3	11.3
14	101RS-3	14.0	11.8	12.5
15	101RS-10	13.2	12.6	9.8
	Mean	13.7	13.0	11.4

1/ Plants making up this polycross came from yellows-infected plants of the "91DS" and the "91DR" selections.

One selection showed a sucrose content of 15.0 percent, while roots of the commercial variety growing beside it on the same bed contained only 12.7 percent sucrose, and the parent growing on the adjacent bed contained only 12.2 percent sucrose.

Additional seed of one selection, which appeared from earlier tests to accumulate sucrose faster than the parent, was planted in one row of a bed with the parent (US 75) in the other row. The changes in percentage sucrose of this selection, the parent, and also the commercial variety were followed at two-week intervals during the growing season. Ten roots of the selection and of the two varieties were taken on each sampling date and the sucrose determined on each individual root. The results are shown in table 3. At no time during the growing season was the concentration of sucrose in the roots of the parent or the commercial variety equal to that of the selection. At the time of the last sampling, the roots of the selection showed 1.1 percentage points higher sucrose than the parent and 2.1 percentage points higher sucrose than the commercial variety.

GROWTH RATE OF HEALTHY AND INOCULATED PLANTS OF YELLOWS-RESISTANT SELECTIONS GROWN UNDER CONTROLLED CONDITIONS

A breeding program for increasing resistance to virus yellows would be greatly facilitated by having a test whereby resistant selections could be identified early and at the same time give an indication as to the vigor these selections may have under healthy conditions. Earlier experiments have indicated that the reduction in growth rate of roots of inoculated plants during an early period of development may be of value in identifying selections which have resistance to virus yellows.

Table 3.

Changes in the percentage sucrose in roots of one yellows-resistant selection, the parent and a commercial variety during the growing season

Sampling Date	Selection 91DS-3 Sucrose	Variety US 75 Sucrose	Variety Spreckels #1 Sucrose
	Percent	Percent	Percent
July 28	12.5	11.5	9.0
August 11	12.9	11.2	9.3
August 24	11.7	10.0	10.5
August 30	--	11.6	10.5
September 15	13.2	11.6	10.1
October 9	13.7	12.6	11.6

An experiment was conducted in the greenhouse, under controlled conditions, in which the growth rate of roots of yellows-inoculated and of healthy plants of the parent and 11 selections was determined.

Seed of the selections was planted in flats in the greenhouse February 13. Fifty seedlings of each selection and of the parent was transplanted to 1-gallon cans 7 days later. A fine river-bottom sand was used for growing the plants. After the small plants had become established, they were watered daily with an excess of Hoagland's solution containing 100 P.P.M. of nitrogen. One month after transplanting, one-half of the plants of each selection was inoculated with a virulent strain of the yellows virus. Sixty days after the plants were inoculated, one-half of each of the healthy and diseased plants of each selection was harvested. All but 4 of the smallest leaves were removed and each root weighed separately. Twenty-one days later the remainder of the roots were harvested. The mean root weight, relative to that of the parent, for the two dates of planting, and the growth rate of the roots during the 21-day growing period are shown in table 4.

Determination of root weight of healthy and yellows-infected plants after two periods of growth ,not only gives a test on the reproducibility of the results but in addition shows the growth rate for the period between the two samplings. The growth rate, therefore, should be a reliable indication of the relative ability of plants of different selections to grow under healthy and yellows conditions.

The healthy plants of 6 selections showed a greater growth rate, during the period tested, than the parent, while the yellows-inoculated

Table 4.

Growth rate of healthy and yellows-inoculated plants of resistant selections grown in the greenhouse under controlled nutritional conditions

Selection and Basis of Selection	Root Wt. Ratio: Selection/Parent X 100 Days of Growth and Condition 90 Healthy	111 Healthy	90 Diseased	111 Diseased	Growth Rate For 21 Days Healthy	Diseased	Ratio Growth Rate D/H X100
US 75 (Parent)	100	100	100	100	2.13	1.56	72
Superior root weight and greater than mean amino acid ratio (Yellows-infected plants)							
91DS-3	108	93	103	108	1.73	1.77	102
91DS-22	112	118**	106	104	2.62	1.59	61
91DS-23	113	115**	117	128**	2.48	2.14	86
91DS-24	104	92	91	95	1.75	1.55	89
91DS-9	99	96	121	121*	2.00	1.88	90
91DS-7	126**	123**	114	118*	2.58	1.90	74
Superior amino acid ratio and greater than mean root weight (Yellows-infected plants)							
91DR-6	70**	74**	78*	92	1.67	1.60	96
Superior amino acid ratio and also a superior root weight (Yellows-infected plants) 1/							
101RS-9	132**	122**	150**	133**	2.41	1.86	77
101RS-3	112	105	146**	118*	2.14	1.48	69
101RS-2	103	94	152**	130**	1.83	1.75	96
101RS-5	137**	126**	119	127**	2.50	2.10	84
Ratio of 100 Equals	37.2 Gm.	82.0 Gm.	26.8 Gm.	59.7 Gm.			

1/ Plants making up this polycross came from yellows-infected plants of both the "91DS" and the "91DR" selections.

*,** Significantly greater, or less, than the parent (US 75) at the 5-and 1-percent level, respectively.

plants of 9 of the 11 selections showed a greater growth rate than the parent during the same period. The roots of 5 selections had a growth rate greater than that of the parent under both healthy and yellows conditions. It is these selections that may, under extensive field tests, where the incidence of yellows is variable, show more promise than selections showing a greater degree of resistance to yellows but slower growth under healthy conditions.

PERCENT SUCROSE IN ROOTS OF HEALTHY AND INOCULATED PLANTS OF YELLOWS-RESISTANT SELECTIONS AND THE PARENT

The healthy and yellows-infected plants of the parent and of the 11 selections, shown in table 4, grown for 90 days in the greenhouse under controlled conditions, were transplanted in a field plot on May 22. Twenty-five roots of healthy and the same number of infected roots of each selection and the parent were planted in rows, using an 8-inch spacing. At harvest, October 10, the roots of each selection were weighed and divided into two 12-beet samples for sugar analysis. The results of this test are shown in table 5.

Although it was necessary for the roots to develop a new top and lateral roots, a considerable amount of root growth occurred during the 133 days the plants were growing in the field. The yield performance of these selections will, of course, require extensive replicated field trials to determine which may be superior to that of the parent.

The sucrose percentage of the uninoculated plants of the selections was lower than that of the uninoculated parent. The sucrose percentage in roots of the yellows-infected plants of certain selections appear to be outstanding compared to that of the parent. Of the 11 selections, 5

Table 5.

Root weight and sucrose percent in roots of healthy and yellows-inoculated plants of resistant selections grown in the greenhouse under controlled conditions for 90 days followed by an additional 133 days growth in the field

Selection and Basis upon Which Selection was Made	Root Wt. Ratio Selection/Parent Healthy	Root Wt. Ratio Selection/Parent Diseased	Sucrose Healthy	Sucrose Diseased	Percentage Points Drop Due To Disease
	X 100	X 100	Percent	Percent	
US 75 (Parent)	100	100	17.6	15.3	2.3
A superior root weight and greater than mean amino acid ratio (Diseased Plants)					
91DS-3	89	82	17.3	16.5	0.8
91DS-22	100	141	16.8	13.5	3.3
91DS-23	132	69	17.0	15.2	1.8
91DS-24	132	90	16.7	15.4	1.3
91DS-9	104	105	16.4	15.9	0.5
91DS-7	114	90	16.6	15.1	1.5
A superior amino acid ratio and greater than mean root weight (Diseased Plants)					
91DR-6	93	110	16.5	15.7	0.8
A superior amino acid ratio and a superior root weight (Diseased Plants) 1/					
101RS-9	146	141	15.8	15.8	0.0
101RS-3	130	158	16.6	15.6	1.0
101RS-2	92	207	16.9	16.3	0.6
101RS-5	126	117	16.2	15.1	1.1
Ratio of 100 Equals	435 Gm	264 Gm			

1/ Plants making up this polycross came from yellows-infected plants of the "91DS" and the "91DR" selections.

had a higher percentage sucrose than the roots of the parent. The relative drop in the percentage sucrose, due to the disease, is even more striking. The percentage sucrose in the roots of the yellows-infected plants of the parent was found to be 2.3 percentage points lower than the percent sucrose in the healthy plants. One selection, 91DS-22, showed a greater drop than that of the parent. The other 10 selections showed a mean drop of only 0.94 percentage points due to the disease, as compared to a drop of 2.3 percentage points for the roots of the parent. The selections that appeared to suffer the least drop in percentage sucrose, due to the disease, were those which had a superior amino acid ratio in the mature leaves of yellows-infected parent plants, and a superior root weight as well. The four selections, made on the above basis, suffered a mean drop of only 0.70 percentage points in sucrose due to the disease.

CHANGES IN THE PERCENTAGE SUCROSE AND WEIGHT OF ROOTS OF UNINOCULATED AND YELLOWS-INOCULATED BEET PLANTS DURING THE GROWING SEASON UNDER FIELD CONDITIONS

The plants were grown in the experimental plot, using a highly uniform selection (F58-554H1). The information pertinent to this test has been given earlier. The plants in four rows were inoculated with a virulent strain of the yellows virus on June 28, while the plants were in the 4-to 6-leaf stage. The ten adjacent rows were left uninoculated. One month following inoculation the sampling was begun and was continued at intervals until October 4. Twenty-five consecutive roots were taken in a row of infected plants. Those plants not showing distinct leaf symptoms were discarded. Roots from the uninoculated plot were taken

in the same manner. Each plant was examined for yellows symptoms. As the season progressed, the uninoculated plants became infected with the yellows virus complex. By the end of the season practically all of the plants showed yellows symptoms with varying degrees of severity. When a sufficient number of apparently healthy plants could not be found, plants showing the mildest yellows symptoms were taken to bring the number of roots to 25. Mean values for the percent sucrose and the root weights are shown in table 6.

On July 28, one month after the plants were inoculated, distinct leaf symptoms were showing. On this date, the roots of the inoculated plants had a significantly higher sucrose content than the uninoculated plants. During the following week the sucrose content of the inoculated plants decreased, while at the same time the roots of the uninoculated plants increased until the percentage sucrose was equal. The sucrose percentage of the roots of the inoculated plants showed a further decrease on the August 8 sampling. During this same period the sucrose percentage of the uninoculated roots remained unchanged. It was not until August 25 that the roots of the uninoculated plants had a significantly greater percentage sucrose than the roots of the inoculated plants and remained so throughout the remainder of the growing season.

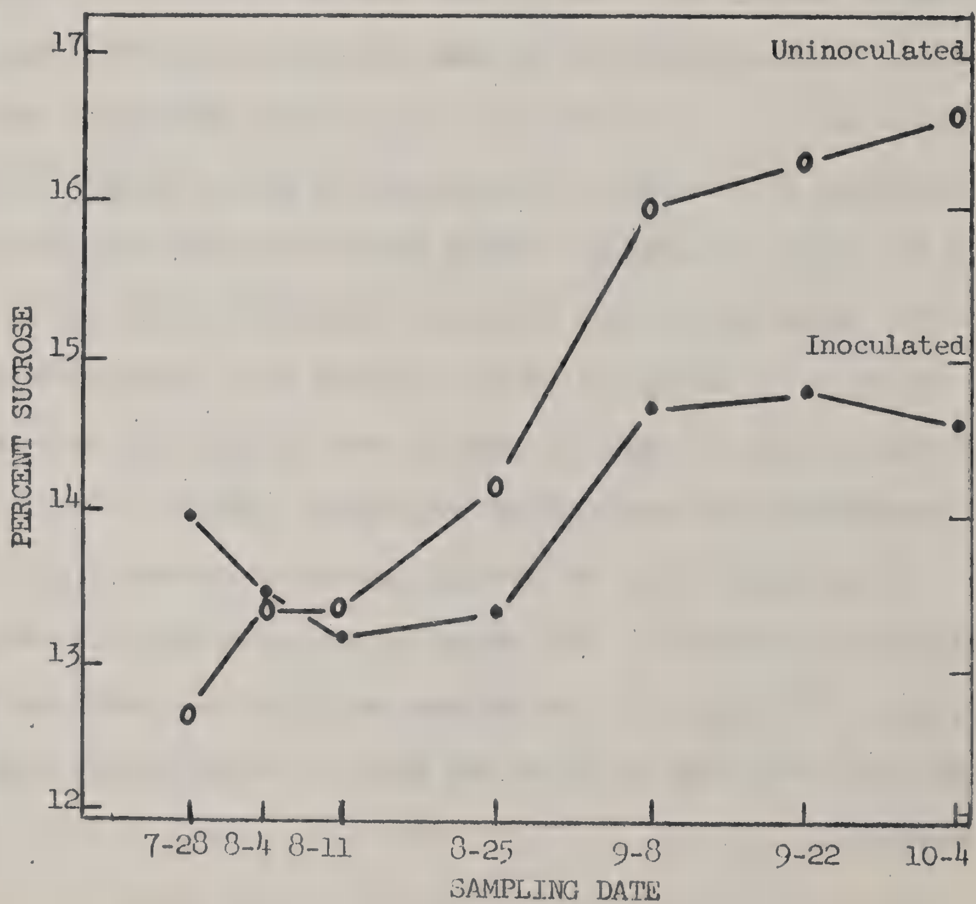
At no time during the growing season was there a significant difference between the root weight of the inoculated and uninoculated plants. The indicated greater root weight of the inoculated plants on the last three sampling dates was apparently due to variation in soil fertility.

Table 6.

Changes in the percentage sucrose and weight of roots of yellows-inoculated and uninoculated beet plants during the growing season.

	Sucrose		Root Wt.	
Sampling Date	Uninoculated	Yellows Inoc.	Uninoculated	Yellows Inoc.
	%	%	Gms.	Gms.
7-28	12.7	14.0**	379	317
8-4	13.4	13.5	463	470
8-11	13.4	13.2	544	476
8-25	14.2**	13.4	733	746
9-8	16.0**	14.7	733	829
9-22	16.3**	14.8	792	910
10-4	16.6**	14.6	842	930

** significantly greater at the 1% level.



In the early stages of yellows, root growth may be greatly retarded temporarily; whereas the ability of the plant to synthesize sucrose may not be impaired during this period. This would account for the significantly higher sucrose percentage in the roots of the inoculated plants at the time the first samples were taken. If this same condition prevails with beets reaching maturity, it is possible that one may expect to find a temporary increase in the percentage sucrose of plants infected late in the season. Table 7 shows the range in percent sucrose and the mean and the coefficient of variation of the percentage sucrose of the uninoculated and inoculated plants.

The range in sucrose percentage of the roots of the uninoculated plants, for the first five sampling dates, is relatively narrow. This is also shown by the very low coefficient of variation ($S/\bar{X}.100$). However, the percentage sucrose in the roots of the last two sampling dates varied over a wide range. This is also shown by the high coefficient of variation which is double that of the sucrose percentage in the roots of the earlier sampling dates.

Table 8 shows the frequency distribution of the uninoculated roots, for percent sucrose, on the different dates of harvest. It is seen from the frequency distribution, of the roots comprising the last two sampling dates, that the much greater range in percentage sucrose is made up of roots having an exceptionally high sucrose content. This is contrary to what one would expect, in view of the lower sucrose percentages encountered in the roots of the inoculated plants.

It is possible that the plants having an exceptionally high percent sucrose in their roots may have become infected with a severe strain of

Table 7.

Range of sucrose percentages and coefficient of variation in sucrose percent in roots of inoculated and uninoculated plants during growing season.

Sampling Date	Uninoculated				Inoculated			
	Range Low	Range High	Mean	Coeff. Var.	Range Low	Range High	Mean	Coeff. Var.
			%	$S/\bar{X}.100$			%	$S/\bar{X}.100$
7-28	11.6	13.9	12.7	4.6	12.1	14.9	14.0	4.9
8-4	12.5	14.8	13.4	4.3	11.8	14.9	13.5	5.3
8-11	12.0	14.8	13.4	5.2	11.6	14.9	13.2	5.0
8-25	12.8	15.5	14.2	5.1	10.9	14.8	13.4	6.6
9-8	14.3	16.8	16.0	4.0	12.1	16.5	14.7	6.1
9-22	14.2	18.2	16.3	8.4	13.1	17.1	14.8	7.3
10-4	14.7	19.5	16.6	7.5	12.2	17.1	14.6	6.5

Table 8.

Frequency distribution of roots 1/ (in percent) for the percentage sucrose, of uninoculated plants grown in the field and sampled at intervals during the growing season.

Sampling Date	Lower Limit of Class, Percent Sucrose									Mean Sucrose
	11	12	13	14	15	16	17	18	19	
	%	%	%	%	%	%	%	%	%	%
7-28	4	60	36							12.7
8-4		28	56	16						13.4
8-11		24	60	16						13.4
8-25		4	36	40	20					14.2
9-8				8	36	56				16.0
9-22				28	16	20	24	8	4	16.3
10-4				4	32	32	16	12	4	16.6

1/ These are the same roots whose range and mean sucrose percent is shown in Table 7.

(Uninoculated plants)

yellows virus late in the season which greatly retarded root growth but did not interfere with storage of sugar.

CURLY TOP RESISTANCE OF SUGARBEET SELECTIONS MADE FOR RESISTANCE TO VIRUS YELLOWS

Some of the yellows-resistant selections, made on the basis of a superior amino acid ratio in the mature leaves of yellows-infected plants and on a superior root weight, were tested along with the parent for resistance to curly top. Seedlings were transplanted to one-gallon cans (one plant per can) containing fine river-bottom sand. The plants were watered with Hoagland's solution. When the seedlings were established they were inoculated with curly top virus, strain 11. Twenty-five plants of each selection and the parent were inoculated September 9, and harvested 77 days later. The infected plants were placed in five severity grades, the fifth grade being those plants that died before the plants were harvested. The plants comprising each grade were weighed. The results are shown in table 9. Three selections, 202S-14, 202S-15 and 302R-15, appear to have more resistance to curly top than their curly-top-resistant parent, US 75. All of the plants of these three selections fell in the first two severity grades; whereas, only 80 percent of the plants of the parent fell in the first two grades. The first two selections, above, had 57 and 64 percent of their plants, respectively, falling in grade one as compared to only 36 percent of the plants of the parent that fell in grade one. Only one selection, 302R-10, appeared to be more susceptible to curly top than the parent. The test indicates that curly top resistance may be retained, or even increased, while making selections for resistance to virus yellows.

Table 9.

Evaluation for curly top resistance of selections which were made for resistance to virus yellows

Selection and Basis upon Which Selection was Made	Healthy	Percent of Infected Plants in Each Grade and Mean Root Wt. Severity Grade 1		2		3		4		Died Before Harvest
	Gm.	%	Gm.	%	Gm.	%	Gm.	%	Gm.	%
US 75 (Parent)	98.7	36.0	75.4	40.0	58.3	20.0	38.4	4.0	16.0	0
Superior root weight and greater than mean amino acid ratio (Yellows-infected plants)										
91DS-9		32.0	70.9	40.0	58.2	28.0	45.8	0	--	0
91DS-22		37.5	73.3	37.5	65.2	25.0	48.3	0	--	0
202S-14		56.6	73.3	43.5	61.5	0	--	0	--	0
202S-20		63.7	70.0	36.3	55.3	0	--	0	--	0
Superior amino acid ratio and greater than mean root weight (Yellows-infected plants)										
91DR-14		25.0	69.6	54.1	49.2	16.7	46.8	4.2	13.2	0
302R-10		8.2	63.5	33.4	37.5	21.8	16.0	25.0	12.0	12.5
302R-15		47.8	62.3	52.2	52.1	0	--	0	--	0
Superior amino acid ratio and a superior root weight (Yellows-infected plants) 1/										
101RS-9		20.8	61.4	50.0	58.6	29.3	46.7	0	--	0

1/ Plants making up this polycross came from yellows-infected plants of the "91DS" and "91DR" selections.

SUSCEPTIBILITY TO CURLY TOP OBTAINED BY SELECTION OF BEET PLANTS FOR SEED INCREASE, ON THE BASIS OF THE CONCENTRATION OF CERTAIN AMINO ACIDS IN THE MATURE LEAVES OF HEALTHY PLANTS

It seemed logical that if resistance to virus yellows is correlated with a high amino acid ratio in the mature leaves of yellows-infected plants, then resistance to virus yellows may be obtained by selection of plants on the basis of the concentration of the amino acids, involved in the ratio, in the mature leaves of healthy plants.

Selections were made on the basis of the concentration of aspartic acid and on the concentration of glutamic acid in the mature leaves of healthy plants of variety US 75 for resistance to virus yellows. Instead of obtaining resistance to virus yellows, a high degree of susceptibility to curly top was obtained from variety US 75 which is resistant to curly top. The results of a test for susceptibility to curly top are recorded here.

Three selections were made, as follows: One hundred-twenty seedlings of curly top-resistant variety, US 75, were planted in sand and grown under controlled nutritional conditions, using Hoagland's solution to water the plants. When the plants were one month old a mature leaf was removed from each plant for analysis. The midrib was removed before the blade was frozen prior to expression of the juice. The concentration of aspartic acid, glutamic acid, and citrulline, plus alanine, was determined by paper chromatography, using water-saturated phenol as the solvent. Those plants having a concentration of aspartic acid and those plants having a concentration of glutamic acid greater than the mean by at least twice the standard deviation for the group

were saved for seed increase. Plants having a superior amino acid ratio, of aspartic plus glutamic to citrulline plus alanine, were also saved for seed increase. Three separate seed increases were made. The seed from the plants making up each group was composited. These three selections, together with the parent, were tested for resistance, using a virulent strain of the curly top virus as described. The results of this test are shown in table 10 and figure 1.

Seventy-six percent of the infected plants of the parent fell into the first two grades. The plants in these grades show relatively mild leaf symptoms and little or no stunting of the tops. In contrast to this, none of the plants selected on the basis of the concentration of aspartic acid or glutamic acid fell into these two grades. It is doubtful if the selection, made on the basis of a superior amino acid ratio, is more resistant than the other two selections, despite the fact that 4 plants were classified as grade 2. Another indication of the susceptibility of these selections is the high percentage of plants that were killed during the early period of growth. Probably more striking evidence of the greater susceptibility of the selections to curly top is the percentage reduction in the weight of the infected plants compared to that of the healthy parent. The weight of the infected plants of the parent was reduced 40 percent. In contrast to this reduction, the weight of the high aspartic acid, the high glutamic acid and the high ratio plants was reduced 76, 85 and 77 percent, respectively, due to curly top. In another test, these three selections were shown to be as susceptible to curly top as selection 742 which is one of the most susceptible known.

It appears that resistance of sugar beets to curly top may be correlated with the aspartic acid and glutamic acid metabolism of the plant.

Table 10.

Susceptibility to curly top of selections, made on the basis of the concentration of certain amino acids in the mature leaves of healthy plants, from a curly top-resistant variety

Selection Basis & Amino Acid Pattern in Leaves of Healthy Plants Making up Polycross	Range	Mean	Healthy	Percent of Infected Plants in Each Grade and Mean Weight Severity Grade 1		2		3		4		Died Before Harvest 5
	Mg.%	Mg.%	Gm.	%	Gm.	%	Gm.	%	Gm.	%	Gm.	%
US 75 (Parent)												
Aspartic Acid	17-116	38										
Glutamic Acid	6-95	35										
A.A. Ratio 1/		1.28	98.7	36.0	75.4	40.0	58.3	20.0	38.4	4.0	16.0	0
401-C High Aspartic Acid												
Aspartic Acid	53-116	64										
Glutamic Acid		31										
A.A. Ratio		1.23		0	--	0	--	50.0	39.7	29.2	14.7	20.7
501-C High Glutamic Acid												
Glutamic Acid	78-95	85										
Aspartic Acid		35										
A.A. Ratio		1.67		0	--	0	--	23.9	36.7	50.0	8.0	20.7
601-C High A.A. Ratio												
Aspartic Acid		35										
Glutamic Acid		52										
A.A. Ratio	2.05-2.34	2.23		0	--	16.0	65.3	28.0	29.0	40.0	11.3	16.0

1/ A.A. Ratio: $\frac{\text{Aspartic acid + glutamic acid}}{\text{Citrulline + alanine}}$

Figure 1. Typical curly top-infected plants of three selections made on the basis of the concentration of three amino acids in the mature leaves of healthy plants.

(A) Healthy plants of curly top-resistant parent.
(B) Curly top-infected plants of parent.
(C) Basis of selection: High amino acid ratio.
(D) High glutamic acid.
(E) High aspartic acid.

Amino acid ratio: $\frac{\text{aspartic + glutamic}}{\text{citrulline + alanine}}$

BREEDING FOR RESISTANCE TO YELLOWS

J. S. McFarlane, C. W. Bennett, and I. O. Skoyen

Selecting for Yellows Resistance

The objective of the breeding program is to develop breeding lines and varieties resistant to the yellows-producing viruses. A survey of a wide range of varieties and breeding lines from both the United States and Europe has failed to uncover lines which are immune or even highly resistant. Lines furnished by Dr. Henk Rietberg[1] of the Netherlands have shown a high degree of tolerance to beet yellows and have been crossed with yellows-tolerant selections from curly-top resistant lines. During 1961, selections have been made from segregating populations derived from these hybrids. Successive selections have also been made from yellows-tolerant lines selected directly from curly-top resistant lines. The development of yellows-resistant inbred lines has been emphasized.

The 1961 selections were made both in the greenhouse and field with major emphasis being placed on the field selections. The greenhouse selections were made from plants grown in six-inch pots and inoculated with a combination of beet and western yellows when the plants were six weeks old. Selections were based primarily on root size and were made when the plants were about four months old.

Results with greenhouse selections have been disappointing. Symptoms tend to be more uniform among plants in the greenhouse than in the field. Very large differences in root size occur, but these differences have proved to be more closely associated with environmental differences

---

[1] Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands.

between pots than with differences in yellows resistance. We have yet to demonstrate a significant gain in resistance from field evaluations of greenhouse selections.

Field selections were made from an April 18 planting and from a July 18 planting. The beets were planted in checkerboard arrangements so that each plant occupied an area 28 x 28 inches. The April planting was inoculated on June 14 and the July planting on August 29, using a combination of beet and western yellows. Aphid populations were high and natural infection with both mosaic and yellows occurred prior to inoculation. Natural infection was especially severe in the July planting in which nearly 100 percent of the plants showed mosaic symptoms by September 1.

Included in the April 18 planting was a group of F_2 populations from crosses between yellows-tolerant selections furnished by Dr. Henk Rietberg and bolting-resistant inbreds from the USDA breeding program at Salinas. Distinct differences in severity of yellowing were observed among the F_2 populations. Differences also existed in root size both among and within the F_2 populations. A total of 280 roots were selected from nine segregating populations grown on 0.6 of an acre.

The July 18 planting was made with seed from yellows-tolerant lines selected in November 1960. Included were selections from US 75, selections from hybrids between Dr. Henk Rietberg's yellows-tolerant lines and USDA curly-top resistant lines, selections from hybrids between a yellows-tolerant American Crystal inbred and USDA curly-top resistant lines, and selections from hybrids between yellows-tolerant lines developed

entirely from USDA breeding material. Top symptoms were relatively uniform in the July planting and selections were based entirely on root size. A total of 430 roots were selected from approximately two acres of beets.

Effect of Beet and Western Yellows on Root Yields

A field test to determine the effect of western yellows, beet yellows, and a combination of beet and western yellows on root yield of sugar beets was planted at Salinas on April 18, 1961. Included in five replications were four commercial varieties, three F_1 hybrids, a yellows-tolerant selection from US 75, and four inbred lines. To reduce border effects, the four inbred lines were planted as a group on one side of the test. The varieties and inbreds were randomized within their respective groups.

The treatments consisting of a noninoculated check, a western-yellows inoculation, a beet-yellows inoculation, and a combination beet-yellows and western-yellows inoculation were arranged in randomized strips across each replication. The variety sub-plots were two rows wide and 33 feet long. Stands were good and the sub-plots were thinned to approximately the same number of plants in each replication. Spraying with aphicides was started as soon as the plants emerged and was continued at one to two-week intervals through August 24. Inoculations were made June 14 with a virulent strain of the beet-yellows virus, with the western-yellows virus, and with a combination of beet-yellows and western-yellows viruses. Infection was somewhat variable in the inoculated plots, ranging from 60 to 100 percent. The lowest percentage infection occurred in the plots inoculated with western-yellows virus alone.

Aphid populations were high throughout the season and the introduction of yellows and mosaic from nearby beet fields could not be prevented. A few plants showed symptoms on June 14 and nearly 100 percent of the plants in the check plots were infected at harvest on October 4. Symptoms in plots inoculated with beet yellows were similar to those in plots inoculated with the combination of beet and western-yellows viruses. The plots inoculated with western-yellows virus were less yellow than those inoculated with beet-yellows virus or the combination of viruses. In most replications, the western-yellows inoculated plots could not be distinguished from the check plots at harvest time.

Yields in the noninoculated plots ranged from 17.55 to 22.91 tons per acre (table 1). Beet yellows caused a reduction in root yields ranging from 15.8 to 33.1 percent in the open-pollinated lines and hybrids. The difference between varieties was not significant. The yields of the same lines and hybrids inoculated with the combination of beet and western yellows were reduced from 24.2 to 42.1 percent. The difference between varieties was significant at the five-percent point.

The yields of the inbred lines were lower than those of the hybrids and the damage from the yellows viruses tended to be more severe. Yields of the inbreds inoculated with beet yellows were reduced from 21.0 to 40.4 percent. Yields of the inbreds inoculated with the virus combination were reduced from 30.6 to 56.9 percent. The differences between inbreds were significant at the one-percent point for both the beet yellows and the virus combination.

Table 1.--Effect of western yellows, beet yellows, and of the combination of beet and western yellows on root yield of sugarbeets at Salinas, California. (Planted April 18 and harvested October 4, 1961).

Variety No.	Description	Acre Yield: Check	Acre Yield: West Yel.	Acre Yield: Beet Yel.	Acre Yield: Beet and West. Yel.	Reduction in Yield: West. Yel.	Reduction in Yield: Beet Yel.	Reduction in Yield: Beet and West. Yel.
		Tons	Tons	Tons	Tons	Percent	Percent	Percent
Open-pollinated lines and hybrids								
011	4th sel. from US 75	17.55	17.15	14.76	13.31	2.2	15.8	24.2
US H5	(MS of NB1 x NB4) x 663	20.05	18.51	15.85	13.83	7.6	20.7	31.2
F58-554H1	MS of NB1 x NB4	22.91	21.72	17.02	15.67	5.1	25.8	31.4
US H2	(MS of NB1 x NB3) x 663	19.63	20.06	14.78	13.03	(2.4)+	24.4	33.0
US H6	(MS of NB1 x NB5) x 663	20.07	18.34	15.01	13.03	8.9	24.7	35.4
F60-547H1	MS of NB1 x NB5	17.96	15.16	13.69	11.06	13.9	23.2	38.8
5511H1	MS of NB1 x NB2	20.28	17.66	14.65	12.34	12.5	27.4	39.0
US 75	F57-68	19.42	17.32	12.96	11.21	9.8	33.1	42.1
	LSD at 5% point					NS	NS	10.7
Inbred lines								
6554	NB4 inbred	12.42	11.21	9.79	8.63	9.6	21.0	30.6
F60-547	NB5 inbred	12.96	10.86	8.44	8.04	12.2	34.8	37.7
5502H1	MS of NB1	15.51	14.92	11.45	9.29	3.8	26.2	40.1
5511	NB2 inbred	13.85	12.21	8.22	5.98	8.6	40.4	56.9
	LSD at 5% point					NS	8.7	2.9

Yield losses were erratic in the western-yellows inoculated plots and differences between varieties and inbred lines were not significant. This erratic behavior can be attributed to the relatively poor infection obtained from the western-yellows inoculations and to the spread of yellows in the noninoculated plots.

Six of the hybrids and the four inbreds included in the 1961 test were also tested in 1960. The yield losses among the hybrids were similar in the two years (table 2). Beet yellows reduced the average yield of the hybrids 23.8 percent in 1960 compared with 24.4 percent in 1961. The combination of beet and western yellows reduced the yield of the hybrids 33.9 percent in 1960 compared with 34.8 percent in 1961. Yield losses among the inbreds were smaller in 1961 than in 1960. The average loss from beet yellows was 38.9 percent in 1960 compared with 30.6 percent in 1961. The combination of viruses reduced yields of the inbreds 46.3 percent in 1960 and 41.3 percent in 1961.

The 1960 and 1961 results show that losses from beet and western yellows are additive. The additional damage caused by superimposing western yellows on beet yellows was approximately one-half of that caused by beet yellows alone. The addition of western yellows increased the damage to the four inbred lines by approximately one-third.

Evaluation of Yellows Resistant Selections

A yellows-tolerant selection from US 75 was evaluated for resistance to western yellows, beet yellows, and the combination of beet and western yellows in the April 18 planting. This selection represented the fourth successive field selection for resistance to beet yellows. The yield of the selection was reduced 15.8 percent by beet yellows and 24.2

Table 2.--Comparisons of yield losses from beet yellows and from the combination of beet and western yellows at Salinas, California, in 1960 and 1961.

	Reduction in Yield			
	Beet Yellows		Beet and West. Yellows	
	1960 Percent	1961 Percent	1960 Percent	1961 Percent
Hybrids				
US H5	26.2	20.7	36.6	31.2
MS of NB1 x NB4	21.5	25.8	32.7	31.4
US H2	24.5	24.4	32.9	33.0
US H6	23.1	24.7	32.6	35.4
MS of NB1 x NB5	21.2	23.2	34.2	38.8
MS of NB1 x NB2	26.2	27.4	34.5	39.0
Average	23.8	24.4	33.9	34.8
Inbred lines				
NB4	33.4	21.0	46.2	30.6
NB5	35.7	34.8	40.0	37.7
MS of NB1	34.0	26.2	44.2	40.1
NB2	52.4	40.4	54.8	56.9
Average	38.9	30.6	46.3	41.3

percent by the combination of viruses compared with reductions of 33.1 and 42.1 percent for US 75 (table 1). Paired analyses showed the selection to be significantly more resistant to both beet yellows and the combination of viruses. The damage from western yellows was not significantly different in the selection and US 75.

The yellows-tolerant selection and the parent US 75 variety were included in three variety trials in 1961. In each of these trials both the root yield and sucrose percentage were not significantly different in the selection and in US 75.

A second field test was planted at Salinas on April 18, 1961, to determine progress made in selecting for resistance to yellows. The degree of resistance was determined by comparing plots inoculated with a combination of beet and western yellows with noninoculated plots. Inoculations were made June 14.

Included in five replications were two Salinas selections from yellows-tolerant lines furnished by Dr. Raymond Hull[1/] of England, two Salinas selections from yellows-tolerant lines furnished by Dr. Henk Rietberg of the Netherlands, a yellows-tolerant selection from an American Crystal line, two monogerm hybrid varieties, two inbreds selected for yellows resistance at Salinas, and a monogerm inbred.

Aphid populations were high and yellows spread to the noninoculated plots in spite of weekly to biweekly spraying with aphicides. Nearly 100 percent of the noninoculated plants showed yellows symptoms at harvest.

Root yields of the open-pollinated lines and hybrids were reduced from 19.5 to 26.3 percent (table 3). The inbred lines were damaged more

[1/] Rothamsted Experimental Station, Dunholme Field Station, Dunholme, Lincoln, England.

Table 3.--Effect of the combination of beet and western yellows on the root yield of sugar beets at Salinas, California. (Planted on April 18 and harvested October 5, 1961).

Variety	Description	Acre Yield Check	Acre Yield Inoculated	Reduction in yield
		Tons	Tons	Percent
Open-pollinated lines and hybrids				
022	Sel. from Hull's M9 S/2	23.05	18.36	19.5
023	Sel. from Hull's L6 S/3	20.60	16.01	21.7
026	Sel. from A. C. 55-RF-393	19.55	14.61	24.2
027	Sel. from IRS 55 M9	19.00	14.49	24.2
028	Sel. from IRS 55 M14	13.28	9.86	25.7
0539H1	(MS of 7515 x 7569) x 0539	20.36	13.58	25.9
F59-63H4	(MS of 7515 x 7569) x 663	17.20	12.80	26.3
	LSD at 5% point			NS
Inbred lines				
0717	Sel. from bolt. res. inbred	16.69	11.41	31.1
0716	Sel. from bolt. res. inbred	12.48	7.83	37.4
0562	Monogerm inbred	12.19	7.25	40.5
	LSD at 5% point			NS

severely and root yields were reduced from 31.1 to 40.5 percent. The yellows-tolerant selections tended to be damaged less severely than were the unselected lines but the differences between lines were not significant.

The lack of variation in resistance observed in this test is probably caused in part by the occurrence of yellows in the noninoculated plots. It is also possible that the lines which had been selected for tolerance to beet yellows reacted differently when inoculated with a combination of beet and western yellows. Additional tests will be required to determine whether or not varieties resistant to beet yellows are also resistant to western yellows.

P A R T XI

RHIZOCTONIA INVESTIGATIONS

Selecting for Resistance and Utilization of Inoculation Techniques

Foundation Project 25

J. O. Gaskill

Research conducted in cooperation with the Botany and Plant Pathology Section, Colorado Agricultural Experiment Station.

RHIZOCTONIA INVESTIGATIONS, FORT COLLINS, COLORADO, 1961 1/

(A phase of Beet Sugar Development Foundation Project 25)

John O. Gaskill 2/

Studies on Rhizoctonia root rot of sugarbeets in 1961 consisted largely of field progeny tests for resistance, utilizing various inoculating techniques. The progenies tested represented a rather wide genetic (sugarbeet) background and several methods of selecting for Rhizoctonia resistance. The field plots were on the Hospital Farm, Ft. Collins, Colorado. The program of selection of roots for resistance and production of seed from such roots was continued.

Inoculation Performed in Different Years

A set of 12 sugarbeet strains or varieties, including parental material and progenies of roots selected for resistance to *Rhizoctonia solani*, was grown in 2 adjoining areas in the same field in 1961 (Experiment R-1). The crop was planted June 21-22, and thinning was performed at the usual stage of plant development, attempting to leave approximately 9-inch spacing. Randomized-block experimental design was used in each area, with plots 1 row x 23 feet in size. In the inoculation year, 14 feet of row per plot received dry, ground, barley-grain inoculum of a highly pathogenic isolate (B-6) of *R. solani* approximately 7 to 10 days after thinning.

1/ A progress report on investigations conducted by the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station, the Beet Sugar Development Foundation, and the Board of County Commissioners of Larimer County.

2/ Plant Pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

Further details regarding the 2 areas are as follows:

(1) West Area (6 replications): Inoculation was performed in 1960 in plots of sugarbeets and other <u>Beta vulgaris</u> material 3/. No inoculum was applied in 1961.

(2) East Area (4 replications): The soil was fallowed in 1960, and inoculation was performed in 1961, only. In 2 replications, the sub-surface method described for the 1960 tests was used 3/. In the remainder, the inoculum was placed in the center of the foliar rosette.

At harvest, all living plants in the 14-foot inoculated area in each plot were trimmed, in a manner similar to that used for mother beets, and washed and weighed. Root yields obtained in this manner are considered more reliable than numbers of surviving plants for measuring relative Rhizoctonia resistance among strains that do not differ greatly in basic yielding ability, and particularly where parent-progeny comparisons are to be made.

As shown in table 1, disease losses in the area inoculated in the preceding year began early and were extremely severe. More than half the plots had no living plants at harvest, precluding reliable variance analyses. Differences among the 12 strains apparently had little if any real meaning under these conditions.

For the area inoculated in 1961, analysis of variance of root yields gave an F-value of 3.10 for strains, indicating the occurrence of highly significant differences among strains. Of special interest (Table 1) is

3/ Sugar Beet Research, 1960 Report: pages 241-251.

Table 1. Comparison of sugarbeet strains, in 1961, under Rhizoctonia conditions created by artificial, post-thinning inoculation of sugarbeets in different years (FortCollins Exp. R-1, 1961)

Description	F. C. seed no.	Inoculum applied in 1960 (6-plot averages) Stand a/ Thin.	Inoculum applied in 1960 (6-plot averages) Stand a/ Harv.	Inoculum applied in 1960 (6-plot averages) Total b/ wt. of roots	Inoculum applied in 1961 (4-plot averages) Stand a/ Thin.	Inoculum applied in 1961 (4-plot averages) Stand a/ Harv.	Inoculum applied in 1961 (4-plot averages) Total b/ wt. of roots
		No.	No.	Lbs.	No.	No.	Lbs.
Pool of 25 seed lots (G.W.S.Co. 5954-2 to 65); Rhizoc. res. sel. from GW 602	Acc. 2476	6.0	0.5	0.45	19.0	3.5	4.63
Pool of 25 seed lots (G.W.S.Co. 5954-66 to 126); Rhizoc. res. sel. from GW 602	" 2477	6.2	0.5	0.66	18.5	3.3	4.39
Pool of 20 seed lots (G.W.S.Co. 5954-128 to 186); Rhizoc. res. sel. from GW 602	" 2478	6.3	0.8	0.51	18.8	5.0	5.89
GW 602-56A; commercial variety; MM	" 2475	7.2	0.2	0.18	17.8	4.8	5.60
Rhizoc. res. sel. from GW 674-56C	SP 611107-0	7.2	0.3	0.36	18.5	7.5	10.13
GW 674-56C; commercial var.; MM	Acc. 2168	5.7	0.0	0.00	17.8	4.0	6.20
Rhizoc. res. sel. "D" from SP 5831-0	SP 611103-0	6.8	0.3	0.22	19.3	5.5	5.38
Rhizoc. res. sel. "H" from SP 5831-0	SP 611104-0	6.8	0.2	0.18	18.3	6.5	7.28
SP 5831-0; LS-BR res. syn. var.; mm	Acc. 2233	4.8	0.7	0.58	18.5	3.5	4.69
Rhizoc. res. sel.; syn. var.; segr. for mm	SP 611152-001	8.8	1.2	0.63	18.5	6.5	5.80
Rhizoc. res. sel.; syn. var.; essentially MM	SP 611153-00	7.7	0.2	0.09	18.0	3.3	4.06
US 401; LS-BR res. com'l. var.; MM	Acc. 2057	8.5	0.2	0.14	17.5	4.0	4.01
General mean							5.713
L. S. D. (5% point)							2.78
L. S. D. (1% point)							3.74

a/ Living plants, per plot (14' of row), immediately after thinning and at harvest.

b/ Total weight of roots of living plants, per plot (14' of row), at harvest; crowns included.

the root-yield comparison between the Rhizoctonia-resistant selection, SP 611107-0, and its parental variety, Acc. 2168 (GW 674-56C). SP 611107-0 exceeded the parent by more than the amount required for significance at the 1-percent level. This comparison acquires added significance when viewed in conjunction with results obtained for the same 2 strains in Experiment R-2.

Inoculation Performed in 1961, only

Miscellaneous Material:

Sixteen sugarbeet strains were compared for Rhizoctonia resistance, in 1961, in Experiment R-2. Randomized-block design with 4 replications was used, except for US 401 which occurred in 8 plots. Details of timing and procedure were similar to those described above for the so-called "East Area". Half the plots of each strain were inoculated by means of the sub-surface method and the remainder by means of the rosette method.

In yield of roots, the interaction, methods x strains, was negligible ($F = 1.13$). The pooled results, disregarding that interaction, are presented in Table 2. It is of interest to note that 4 of the selections were significantly above US 401 in root yield. Two of those selections (SP 611104-0 and SP 611107-0) also were significantly above US 401 in Experiment R-1 (Table 1, 1961 inoculation).

In parent-progeny comparisons in Experiment R-2 (Table 2), it is particularly noteworthy that the selection, SP 611107-0, significantly exceeded the parental variety, Acc. 2168 (GW 674-56C), in root yield. These results are in agreement with those obtained from 1961 inoculation in Experiment R-1 where the difference was highly significant (Table 1).

Table 2. Comparison of sugarbeet strains for resistance to Rhizoctonia; artificial inoculation performed after thinning (Fort Collins Exp. R-2, 1961)

(Results given as 4-plot averages except where otherwise indicated)

Description	F. C. seed no.	Stand a/ Thin.	Stand a/ Harv.	Total b/ wt. of roots
		No.	%	Lbs.
SP 5831-0 mm (single plt.) ♀x misc.; Rhiz. res. sel.	SP 601156-2	18.0	43.0	4.17
SP 591101-0 mm (" ") ♀x " ; " " "	SP 601156-7	17.5	31.1	4.10
SP 601156-7 (" ") ♀x " ; " " "	SP 611152-7	18.3	37.6	6.52
Syn. var.; segregat. for mm; Rhiz. res. sel.	SP 611152-001	17.8	36.3	4.19
Rhiz. res. sel. "D" from SP 5831-0	SP 611103-0	17.0	25.6	4.98
" " " "H" " " "	SP 611104-0	17.8	46.6	7.34
SP 5831-0; mm; LS-BR res. syn. var.	Acc. 2233	18.5	32.4	5.42
Syn, var.; essen. MM; Rhiz. res. sel.	SP 601157-00	18.3	18.8	3.54
Rhiz. res. sel. "D" from G. W. S. Co. C 817	SP 611105-(01)	17.0	24.7	5.03
" " " "H" " G. W. S. Co. C 817	SP 611105-(02)	18.0	40.2	6.70
G.W.S. Co. C 817; MM; incr. of Powers' sel. A54-1 syn.	Acc. 2232	18.3	22.8	4.32
Rhiz. res. sel. from GW 674-56C	SP 611107-0	19.0	42.9	8.38
GW 674-56C; MM; commercial var.	Acc. 2168	17.3	20.2	4.09
Rhiz. res. "D" sel. from US 401	SP 611106-(01)	19.0	18.7	4.33
" " "H" " " " "	SP 611106-(02)	16.5	21.7	3.64
US 401; MM; LS-BR res. com'l. var.	Acc. 2057	18.1 c/	14.8 c/	2.65 c/
General mean				4.826
L. S. D. (5% point) for comparison of 4-plot means				3.71
L. S. D. (5% point) for comparison of 8-plot mean with 4-plot means				3.22

a/ Living plants, per plot (14' of row), immediately after thinning and at harvest. The number living at harvest is expressed as percent of the number immediately after thinning.

b/ Total weight of roots of living plants, per plot (14' of row), at harvest; crowns included.

c/ 8-plot averages (Acc. 2057, only).

Pooling of these 2 sets of results (8 plots of SP 611107-0 and 8 plots of the parent, Acc. 2168), shows that SP 611107-0 exceeded the parent by 79.9% -- an amount considerably greater than that required for significance at the level, odds 99:1.

Other parent-progeny comparisons in Table 2 reveal a tendency for the progenies to be higher in root yield, but the differences are much less impressive than in the case of SP 611107-0 _vs_. Acc. 2168.

Selections from GW 602:

A number of seed samples, representing individual plants selected under natural (field) Rhizoctonia conditions in Nebraska and Wyoming, were furnished by the Great Western Sugar Company. Three pools, made up from those seed lots, were included in Experiment R-1. Fifty-three of the individual samples were planted in 2 plots, each, with randomized-block arrangement, for preliminary Rhizoctonia-resistance screening. GW 602-56A, the parental variety, was planted in 8 plots throughout the test area. Except for replications, the methods used were the same as described above under the heading, "Miscellaneous Material".

Average stand (living plants) at harvest, expressed as percentage of thinned stand, was 17.5 for GW 602-56A and 24.4 for the set of 53 progenies. Analysis of variance for the progenies indicated that they did not differ significantly in root yield ($F = 1.06$). Average root yield, in pounds per plot, was 3.6175 and 4.6635 for GW 602-56A and progenies, respectively. The difference (1.0460) was substantially less than that required for significance at the 5-percent level. The latter, as computed, was 1.5010. However, because of frequent occurrence of zero yield for individual plots, the computed L. S. D. figure (1.5010)

presumably is somewhat smaller than the true L. S. D.. The relatively small difference in yield between GW 602-56A and the progeny average, in this test, is in agreement with the results obtained in Experiment R-1 (Table 1). However, it is of interest to note that several individual progenies exceeded GW 602-56A, in root yield, by an amount closely approaching or greater than the 5-percent level of significance. Those progenies are listed below, together with their respective average root yields:

G.W.S.Co. no.	Pounds per plot
5954-2	8.31
5954-92	7.24
5954-96	9.80
5954-145	7.87
5954-186	7.37
GW 602-56A	3.62
Approximate L.S.D.	3.96

Further work with the above 5 progenies -- e.g. retesting, reselection, or both -- appears to be highly desirable.

Discussion and Conclusions

Under severe exposure to Rhizoctonia, resulting from post-thinning inoculation in 1961, normally productive strains of sugarbeets differed very significantly in yield of roots at harvest. Since Rhizoctonia was the principal factor limiting root yield, these differences were interpreted as strong evidence that the strains differed in resistance to the pathogen. Under more intense exposure, resulting from inoculation of the beet crop

in the preceding year, severe disease activity began very early in the development of the 1961 test plants, and by harvest, differences in resistance appeared to be negligible.

Evidence of improvement of Rhizoctonia resistance by selection was encouraging, particularly for SP 611107-0, a selection from GW 674-56C. Where Rhizoctonia inoculation was performed after thinning in 1961, resulting in severe root rot conditions, the average root yield for 8 plots of SP 611107-0 was 79.9% above the comparable 8-plot average for the parental variety, a highly significant difference. In considering the meaning of these results it should be noted that the roots grouped to produce the seed lot, SP 611107-0, were selected under Rhizoctonia conditions that had been created in a rather unique way. Sugarbeet plots, inoculated in 1959 with a mixture of pathogenic isolates of the fungus, suffered very severe root rot losses. In the following year, the entire area was planted with GW 674-56C, but no inoculum was applied. Stand loss was almost complete, and the few surviving plants were used to produce SP 611107-0. It is conceivable that the superior performance of SP 611107-0 may be due in part to the use of this selection procedure.

PART XII

DEVELOPMENT OF BASIC BREEDING MATERIAL AND APPLICATION OF FIELD TECHNIQUES

- - -

SCREENING TESTS FOR BLACK ROOT RESISTANCE

- - -

APPLICATION OF FUNGICIDES FOR CONTROL OF CERCOSPORA LEAF SPOT

Foundation Project 26

G. E. Coe   H. L. Bissonnette [1/]   C. L. Schneider

1/ Research conducted in cooperation with Minnesota Agricultural Experiment Station.

DEVELOPMENT OF BASIC BREEDING MATERIAL

G. E. Coe

Most of the research at Beltsville under Foundation Project 26 has been directed toward varietal improvement in resistance to Cercospora leaf spot and black root. Breeding material produced by this research program has contributed to the varieties and new developments that are evaluated in tests reported in Part IV. This part of the report presents some results obtained with polyploid lines, some curly-top- and leaf-spot-resistant lines, a test of Cercospora leaf-spot inoculum from two different sources, and a test of a new soil conditioner.

Polyploidy

A test was conducted in 1961 to determine the performance of "comparable" diploid and triploid hybrids. It was similar to the test described in the 1960 Sugar Beet Research Report. The triploid hybrids in the 1960 test had two genomes (two sets of chromosomes) from SLC 91MS monogerm, which is not resistant to black root or leaf spot, and one genome (one set of chromosomes) from SP 5481-0 (multigerm), which is fairly resistant to these two diseases. The diploid hybrid had one genome from each parent. The 1960 data indicated that the triploid hybrid had slightly less leaf spot resistance and lower yield than the diploid hybrid.

The hybrids for the 1961 test were produced by crossing SL 122MS diploid monogerm and SP 5720-01 W.A. monogerm with both diploid and tetraploid US 401 multigerm in separate isolation plots. In these hybrids, the triploid from SL 122MS mm X US 401 MM 4n had one genome from the leaf

spot and black root susceptible SL 122MS and 2 genomes from US 401 which has a good degree of resistance to these diseases. In Table 1 are data from paired plots of the triploid and "comparable" diploid hybrids.

TABLE 1.--Comparison of triploid and diploid hybrids in paired 4-row plots.

Hybrid variety	Average leaf spot reading 1/	Calculated tons/acre	Average percent sucrose	Average percent purity
Triploid SL 122MS X US 401 4n 2/	5.20	12.88	11.27	73.92
Diploid SL 122MS X US 401 2n 2/	5.50	11.29	11.30	77.73
Triploid 5720-01 WA X US 401 4n 3/	5.00	13.78	10.80	74.48
Diploid 5720-01 WA X US 401 2n 3/	5.50	10.69	12.00	76.43

1/ Leaf spot readings are based on a scale of 0 to 10. 0 = immunity; 10 = all leaves dead, caused by leaf spot.

2/ Data given as averages of three 4-row plots.

3/ Data given as values of one 4-row plot.

Although the differences were not great, the triploid hybrids appeared to be more resistant to leaf spot, to have a better yield, and to have poorer purity than the diploid hybrids. The data from the 1960 and 1961 nursery tests tentatively indicate: (1) that the degree of resistance to leaf spot and the yield are related to the parent contributing the diploid gametes, in cases where one parent has resistance to the disease and the other parent does not; and (2) that the triploid hybrids tend to accumulate more nonsugar solids than do the diploid hybrids.

Breeding for Curly Top and Leaf Spot Resistance

A program of selecting sugarbeets for the purpose of producing a variety resistant to both curly top and Cercospora leaf spot has been in progress for many years. Professor J. C. Overpeck at University Park, New Mexico, made the selections for curly top resistance. Two years later, the seed increase of these selections was planted at Beltsville for a selection for resistance to leaf spot. Two years later, the seed increase of the Beltsville leaf spot selections was again selected for curly top resistance in New Mexico, etc. There has developed from this line of breeding a multigerm variety, SP 6051-0, which in the 1961 test had more resistance to leaf spot than US 401 and resistance to curly top approaching that of US 41 (028). Crosses of the progenitors of SP 6051-0 have been made with leaf-spot- and black-root-resistant monogerms. Twenty-two F_3 monogerm lines recovered from these crosses were tested in 1961. These lines generally fell into a curly top resistance category with US 33 and a leaf spot resistance category one step below US 401 (table 2). The 1961 Beltsville selections of these monogerms are to be crossed with Beltsville selections of SP 6051-0; the New Mexico selections of the monogerms will be increased and sent to Beltsville for leaf spot selection. The present goal is to develop a monogerm variety with as much (or more) resistance to the two diseases as the multigerm, SP 6051-0.

Test of Source of Inoculum on Severity of Leaf Spot Epidemic

Data were presented in the 1960 Sugar Beet Research Report indicating that inoculum prepared from leaves of a variety resistant to _Cercospora beticola_ produced a slightly more severe epidemic than did inoculum collected

TABLE 2.--Performance of curly top resistant-leaf spot resistant varieties in 1961 trials. 1/, 2/

	Curly Top			Leaf Spot	
	Jerome, Idaho		New Mexico	New Mexico	Beltsville
Variety	%	Grade	Av. grade	Av. grade	Av. grade
202 H9 check	----	--	2.2	6.7	----
R 5651 check	----	--	3.2	6.5	----
US 41 (028) check	51.0	4	---	---	----
SL 333 check	94.0	5	7.8	7.3	----
SL 122MS X SP 5460-0	----	--	3.8	5.5	5.75
SP 6051-0	56.3	3	2.0	3.0	4.75
SP 60100-01	----	--	4.0	4.0	4.00
SP 60101-01	----	--	6.0	4.0	5.00
SP 60102-01	----	--	3.0	4.0	5.00
SP 60103-01	93.0	4	6.0	4.0	5.00
SP 60104-01	95.0	4	4.0	5.0	5.00
SP 60105-01	96.5	4	5.0	5.0	4.75
SP 60106-01	93.0	4	4.5	5.3	5.00
SP 60107-01	98.4	5	4.1	4.7	4.50
SP 60108-01	95.5	4	3.0	7.0	5.00
SP 60109-01	91.0	5	5.0	4.0	4.75
SP 60110-01	90.0	5	5.0	6.0	5.00
SP 60111-01	90.9	5	5.0	5.0	5.00
SP 60112-01	98.4	5	5.0	6.0	5.00
SP 60113-01	99.0	5	6.0	5.0	4.75
SP 60114-01	93.9	5	4.5	4.4	4.75
SP 60115-01	93.5	5	5.0	5.0	5.00
SP 60116-01	95.7	4	4.0	4.0	4.75
SP 60117-01	92.2	4	4.0	5.0	5.00
SP 60118-01	96.5	5	5.0	4.0	4.25
SP 60119-01	92.2	5	4.0	5.3	5.00
SP 60120-01	89.0	5	4.8	5.1	5.00
SP 60121-01	91.6	5	4.0	5.0	5.00

1/ Basis of readings (both diseases): No. 1 = best; most resistant. No. 10 = poorest; least resistant.

2/ Disease readings from the New Mexico test were made by Prof. J. C. Overpeck; curly top readings at Jerome, Idaho, were made by Mr. A. M. Murphy.

For further information on New Mexico test, see page 82.

from susceptible varieties. The experiment was repeated in 1961, but on a larger scale. Alternate 6-row strips through the nursery plot were inoculated with inoculum prepared from leaves collected from resistant varieties; the other strips were inoculated with inoculum prepared from leaves collected from susceptible varieties. This resulted in one replication of each experiment receiving inoculum of one type, while the other replication received inoculum of the other type. The total leaf spot readings of these replications are presented in table 3.

TABLE 3.--The influence of the source of inoculum on the severity of leaf spot epidemic.

	Total leaf spot reading of 36 entries in each replication[1/]			
	August 1 reading		August 12 reading	
Experiment Number	Inoculum from leaves of susceptible varieties	Inoculum from leaves of resistant varieties	Inoculum from leaves of susceptible varieties	Inoculum from leaves of resistant varieties
1	153	144	170	162
2	140	142	147	167
3	143	151	184	188
4	165	133	176	164
5	169	140	176	170
6	164	136	181	174
11	129	129	172	176
12	144	134	161	160
Average	150.8	138.6	170.9	170.1

1/ The higher the numerical rating, the more severe the leaf spot epidemic.

The inoculum prepared from the susceptible varieties produced a slightly more severe leaf spot epidemic in five of the experiments; the inoculum from the resistant varieties produced a slightly more severe leaf spot epidemic in two of the experiments; and in one experiment there was essentially no difference in the severity of the disease. The average readings for all eight experiments on August 1 indicate a slightly more severe epidemic in

plots inoculated with inoculum from susceptible varieties, and no difference in disease epidemic at the time of the second reading on August 12. Thus, the data are in conflict with those obtained in 1960, indicating that some factor other than souce of inoculum, per se, influenced the severity of the epidemic. Another test is planned for 1962 to try to resolve the difference in the results obtained.

Asphalt Emulsion Soil Conditioning Test

A new asphalt emulsion product to prevent soil crusting was in a preliminary test at Beltsville in 1961. One row of each of 4 varieties was planted across the nursery plot on April 26. The asphalt emulsion spray was applied to alternate 20-foot sections down the 4-row plot on April 28. Great difficulty was encountered in applying the emulsion. A knapsack sprayer was completely clogged after spraying only 3 feet of row. Application was finally made with a watering can with a rosehead spout. This also became clogged after application to about 50 feet of row, but application was possible by periodically cleaning the rosehead. The spray produced a black "rubber-like" film on the surface of the soil, which remained until the beets were singled on June 5. On May 3 at 11:10 a.m. E.D.T., soil temperatures at a depth of 1 1/2 inches were taken. It was found that the plots with the asphalt emulsion were approximately 5° F. warmer than the untreated checks. It was also noted that the seedlings emerged from 12 to 24 hours quicker on the treated plots. Conditions for seedling emergence were excellent at Beltsville in 1961, and a perfect emergence was obtained over the entire experiment. Although more seedlings emerged in the treated plots, the difference was not significant.

STUDIES ON BLACK ROOT DISEASE CAUSED BY APHANOMYCES COCHLIOIDES

C. L. Schneider

1. Greenhouse Screening Tests for Resistance

A series of inoculation tests was conducted in the greenhouse to determine the degree of resistance to the seedling blight and root rot fungus, *Aphanomyces cochlioides*. Included were 761 sugarbeet breeding strains and 38 *Beta maritima* strains. Each entry was grown in four replicated saucers of steamed soil in randomized blocks. After emergence, plants were thinned to a maximum of 25 per saucer. Approximately 14 days after planting, plants were inoculated by pouring 50 ml. of a water suspension of zoospores of a monosporous isolate of *A. cochlioides* into the soil in each saucer.

The degree of disease severity was determined, based on the number of plants surviving approximately 30 days after inoculation and the severity of symptoms of the surviving plants. Included in each test, as a basis for comparison, was the moderately resistant commercial variety, US 401.

The results are presented in table 1. Although none of the entries was immune, a considerable number were more resistant than variety US 401.

The average disease ratings of the breeding strains, expressed in percent of that of variety US 401, were lower than in previous years, indicating a further rise in the level of Aphanomyces resistance.

As previously noted, the level of resistance of the *Beta maritima* strains was not equal to that of the improved sugarbeet breeding strains. There were considerable differences among them in degree of resistance, and a few appeared to be as resistant as US 401.

TABLE 1.--Distribution of entries in Aphanomyces screening tests according to disease rating.

Types of material	No. of entries	Average disease rating	Number of entries in each disease rating class[1]							
			70	80	90	100	110	120	130	140
Sugarbeet breeding strains:										
Multigerm diploid	114	88.5	1	37	57	17	2	-	-	-
Multigerm tetraploid	239	104.1	-	1	29	92	105	11	1	-
Monogerm diploid	374	93.0	5	52	183	101	24	9	-	-
Monogerm hybrid diploid	34	83.8	-	5	13	13	2	1	-	-
Beta maritima strains:	37	115.0	-	-	2	2	13	15	4	1

[1] Disease rating = percent disease as compared with sugarbeet variety US 401, which is 100. The higher the rating, the greater the amount of disease.

2. Factors Influencing Zoospore Production by *Aphanomyces cochlioides*

Large quantities of zoospore inoculum are regularly used in greenhouse screening tests of Aphanomyces resistance at the Plant Industry Station, Beltsville, Maryland. In order to establish a methodology for production of ample quantities of inoculum, studies were made to determine the main factors influencing zoospore production.

Cultures of the fungus were grown in flasks of .3 percent peptone or .3 percent Soytone broth. Mycelial mats thus produced were rinsed in sterilized tapwater and submerged in replacement water (usually additional sterilized tapwater) for about 16 hours. Numbers of zoospores thus produced were determined with a haemacytometer.

The factors studied and their observed effects on zoospore production are as follows:

a) Temperature. As reported previously, temperature has a profound effect upon zoospore production. Maximum production occurs between 20° and 25° C. and falls sharply beyond these limits; therefore, all further tests of spore production were conducted at temperatures within these limits.

b) Type of replacement water. The type of water in which the mycelial mats are submerged plays an important role. Tapwater was superior to distilled water and to distilled water that had been passed through a "Deeminizer" demineralizing apparatus. Zoospore production in each type of water, and especially distilled water, was intensified by the addition of sodium chloride (120 mg per liter).

c) Aeration. Bubbling a small amount of air continuously through the replacement water increased zoospore production 1 to 3 times over that of the controls.

d) Age of culture. Zoospore production was greatest among mycelial cultures that had just attained maximum diameter in the flasks and which were from 4 to 7 days old. Cultures 11 days old, and older, produced relatively few spores. The time in which mycelial cultures attain the degree of growth for most effective zoospore production varies according to temperature, with optimum growth between 25° and 30° C.

e) Depth of replacement water. Depth of water in which mycelial mats are submerged influences zoospore production. With equal amounts of water in vessels of different diameters, zoospore production increased

with a decrease in depth from 26 to 3.2 CM. In extremely shallow vessels with depth less than 1 CM, a decrease in production occurred, due probably to insufficient water to cover the mats.

b) Volume of replacement water. Zoospore production increased with increased volumes of replacement water up to the point where the ratio between the volume of broth in which the mats were grown and the volume of replacement water equaled 1:4. Beginning at this ratio, increasing the number of mycelial mats in the replacement water did not increase proportionally the number of zoospores produced.

g) Light. There were no significant differences in zoospore production between mycelial mats exposed to continuous fluorescent light during period of submergence and those in the dark.

h) Hydrogen-ion concentration. In a series of buffered solutions, optimum zoospore production was at pH 6.5-7.2 and decreased markedly on either side of these limits.

i) Components of nutrient broth. The most satisfactory media for growing mycelial mats to produce zoospores have been .3 percent peptone broth and .3 percent Soytone broth. The latter is the trade name of an enzymatic hydrolysate of soybean meal prepared by Difco Laboratories, Detroit, Michigan. No increase in zoospore production was obtained by adding .1 percent or .3 percent of the following sugars to peptone broth: dextrose, maltose, sucrose, and dextrose.

3. Studies on Physiologic Specialization of *Aphanomyces cochlioides*

A series of inoculation tests were made in the greenhouse to determine the existence of pathogenic races of *A. cochlioides*. Several sugarbeet

strains and varieties were inoculated with zoospores of 11 single spore isolates of the fungus. The isolates were obtained from diseased sugarbeets grown in soils from six widely separated areas in the United States.

Results of the tests are summarized in table 2. All of the isolates were pathogenic on each sugarbeet host variety. Differences in virulence among the isolates are evident, but there is no indication of a significant interaction between host varieties and fungus isolates. For example, the variety US 22/3 was highly susceptible to all isolates; whereas variety 553106-1 was comparatively resistant to all isolates.

Although these tests did not reveal any pathogenic races that could affect the program of developing black root resistant varieties, they did not disprove the possibility of their existence. In regard to other species of Aphanomyces, King and Bissonnette[1] showed that there are pathogenic races of *A. euteiches*, which causes a root rot of peas. McKeen[2] showed differences in morphology and pathogenicity among isolates of *A. cladogamus*, a parasite of peppers. Further studies with additional hosts and isolates should provide additional information concerning the extent of physiologic specialization of the black root fungus, *Aphanomyces cochlioides*.

1/ King, T. H., and H. Bissonnette. 1954. Physiologic specialization in *Aphanomyces euteiches*. Phytopath. 44: 495 (abstract)

2/ McKeen, C. D. 1952. *Aphanomyces cladogamus* Drechs.. A cause of damping-off in peppers and certain other vegetables. Can. Jour. Bot. 30: 701-709.

TABLE 2.--Reaction of sugarbeet strains to 11 single-spore isolates of *Aphanomyces cochlioides* in the greenhouse.

Sugarbeet Variety No.	Aphanomyces rating[1] of each sugarbeet variety inoculated with each isolate												
	61-B	61-G	61-J	61-N	61-P	75-A	78-E	80-D	121-A	144-A	144-B	Mean	Range
US 22/3	6	-	-	5	-	-	-	6	-	-	-	6.4	5-8
SP 55868-1	5	-	5	4	-	5	4	5	-	-	-	4.7	4-5
Acc. 1380	4	-	5	4	-	5	4	4	-	-	-	4.3	4-5
SP 553184-1	4	-	4	4	-	5	4	4	-	-	-	4.0	3-5
SP 55844-1	5	-	4	3	-	4	4	4	-	-	-	4.0	3-5
SP 55877-1	3	-	3	3	-	3	2	3	-	-	-	2.8	2-3
SP 55823-1	3	-	2	4	-	2	-	4	-	2	2	2.7	2-4
SP 553106-1	2	2	-	3	3	2	2	3	-	-	-	2.4	2-3
SP 59265-1	-	-	-	-	-	-	-	1	2	-	-	1.5	1-2

1/ Aphanomyces susceptibility rating expressed in a scale from 1 (degree of susceptibility about 70 percent of US 401) to 8 (degree of susceptibility 140 percent of US 401). A rating of 4 = that of US 401, included in each test for comparison.

FUNGICIDE-OIL SPRAY TEST FOR CONTROL OF CERCOSPORA LEAF SPOT OF SUGARBEETS

C. L. Schneider

Oil sprays are commonly used to control leaf spot disease of banana caused by *Mycosphaerella musicola* (*Cercospora musae*). It has been reported that oil sprays can also control Cercospora leaf spot diseases of citrus and of tung.

The following study was made to determine the possibility of controlling Cercospora leaf spot of sugarbeets with low volume oil spray alone or in combination with certain fungicides. The experiment was conducted in 1961 under severe and sustained exposure to *Cercospora beticola*.

Materials and Methods

The following preparations, furnished by Esso Research and Engineering Company, Linden, New Jersey, were tested:

EAP-1 (a petroleum oil)
EAP-72 (1.25 lb. Maneb per gal. EAP-1 oil)
EAP-73 (0.5 lb. copper oxychloride per gal. of emulsion of: 1 part EAP-1 oil: 3 parts water)
EAP-74 (1 lb. tri-basic copper sulfate per gal. EAP-1 oil)

The experimental design consisted of plots sprayed with each of the preparations and the untreated controls arranged in a 5 X 5 Latin square. Each plot comprised four 20-foot rows, spaced 2 feet apart, of the commercial monogerm hybrid, SL 122MS X SP 5481-0.

On June 23, Cercospora inoculum was applied on all plants by G. E. Coe. By July 10, leaf spot lesions had begun to appear. A severe leaf spot epidemic prevailed in the nursery during August and September.

The preparations were applied with a "Solo Port" knapsack type mist blower on the following dates: July 10, 20, 31; August 14, 25, 28 (after heavy rains of August 25 and 26); September 7 and 22. All preparations except EAP 73 were applied at the rate of approximately 1 gallon per acre. EAP 73 was applied at 4 gallons per acre on July 10 but on subsequent dates was applied at 1 gallon per acre because foliage injury was associated with the higher rate of application.

Between applications, the solid materials in the oil-fungicide preparations settled in compact masses. This necessitated a vigorous stirring with a paddle immediately before pouring the preparation into the tank of the mist blower.

Leaf spot severity readings were made on July 30, August 14, and September 25.

On October 4, the two center rows of each plot were harvested and weighed. All plants in each harvested row were used for determination of sucrose percentage and refractometer readings.

Results

The fungicide-oil preparations reduced leaf spot damage considerably (table 1). The oil alone gave less control. Each treatment increased root yield and percent sucrose in about the same degree that it reduced leaf spot (figures 1 and 2). There were no significant differences in coefficient of apparent purity among any of the treatments.

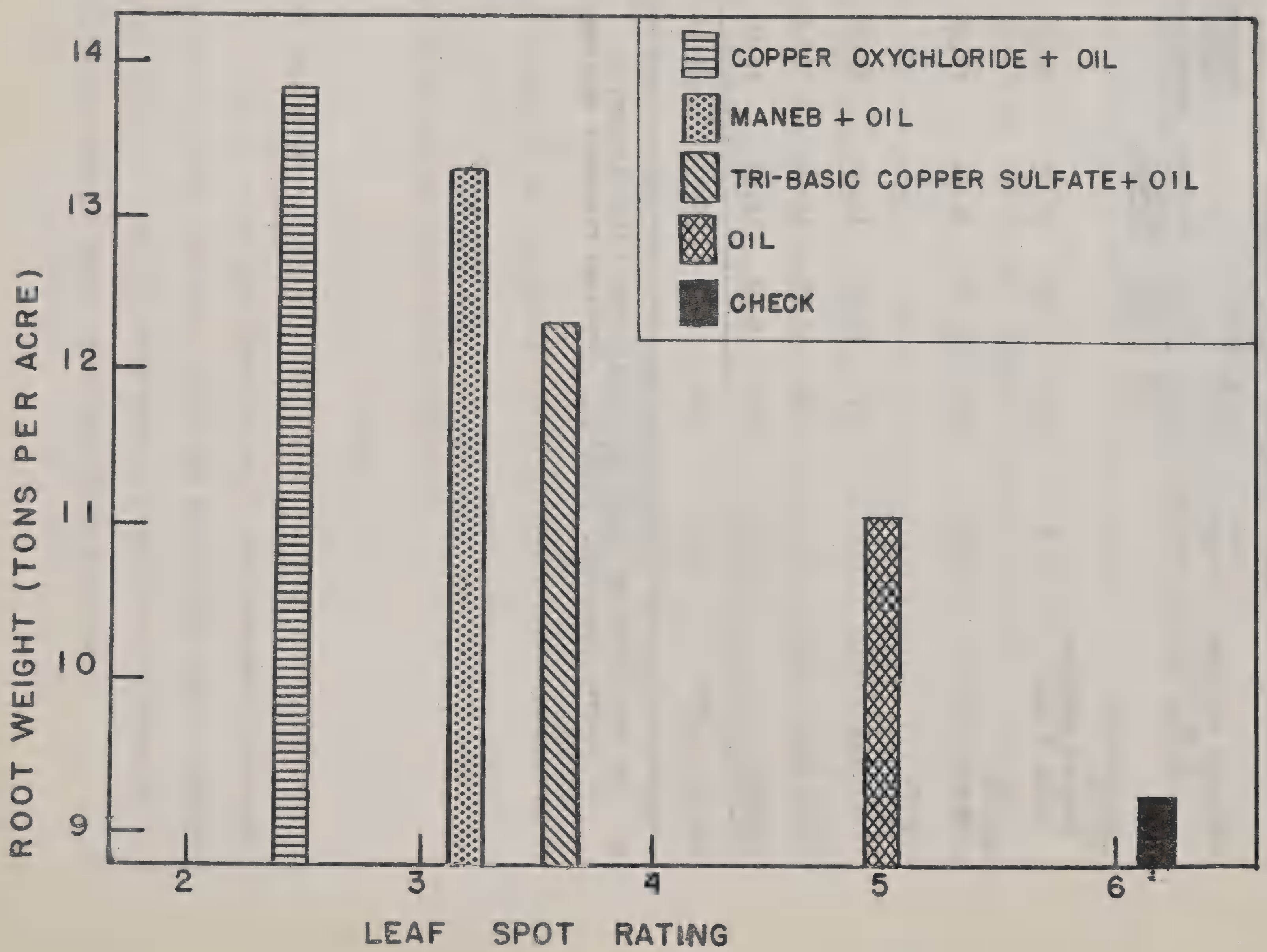
Results of fungicide spray test for control of *Cercospora beticola*
Beltsville, Maryland, 1961

(Results given as 5-plot averages)

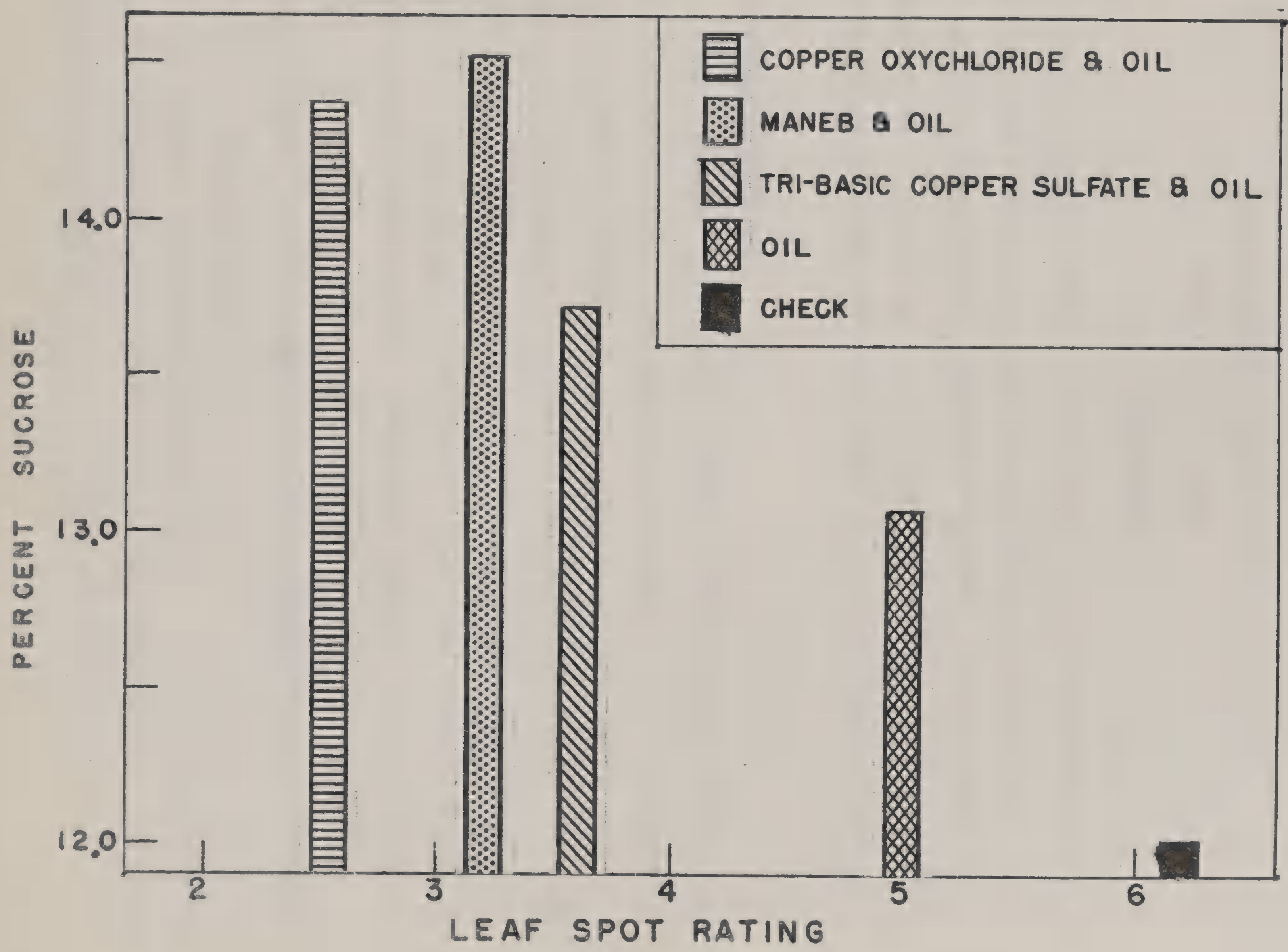
(Variety SL 122MS X SP 5481-0)	Leaf spot reading[a]	Acre yield Gross Sugar	Acre yield Roots	Sucrose	Apparent purity coefficient
		Pounds	Tons	Percent	
EAP-73 (Copper oxychloride + oil)	2.5	3986	13.86	14.38	80.52
EAP-72 (Maneb + oil)	3.2	3832	13.21	14.51	79.35
EAP-74 (Tri-basic copper sulfate + oil)	3.6	3373	12.30	13.72	79.98
EAP-1 (Oil alone)	5.0	2887	11.06	13.07	78.63
Control	6.2	2255	9.29	12.14	77.44
LSD (P = .05)	1.0	569	1.40	0.67	N.S.

a/ Leaf spot readings based on a scale from 0 (no disease) to 10 (leaves completely blighted). Readings represent maximum rating.

THE EFFECT OF FUNGICIDE AND OIL SPRAYS ON CERCOSPORA LEAF SPOT AND ROOT WEIGHT OF SUGAR BEETS



THE EFFECT OF FUNGICIDE AND OIL SPRAYS ON CERCOSPORA LEAF SPOT AND ON PERCENT SUCROSE OF SUGARBEETS



1961 Evaluation of Fungicides for the Control of Cercospora Leaf Spot and Effects on Yield of Sugar Beets

H. L. Bissonnette

Seven fungicides were evaluated for the control of Cercospora Leaf Spot and their effect on the yield of sugar beets at the University of Minnesota Experiment Station, Rosemount, Minnesota. The fungicides were applied at their recommended rates. Where the fungicides were compatible, one gallon of oil (Esso EAP-1) was added to the water fungicide mixture.

Materials and Methods:

Sugar beet seed of the variety American 3 S' was planted May 15. This seed was supplied by the American Crystal Sugar Company. The seedling stand was adequate for the area and was thinned by hand June 20. The experiment was designed as a randomized block with 12 treatments and four replications of each treatment. The experimental plots were four rows wide and 30 feet long with a row spacing of 22 inches. Each plot was separated by a single row and the experiment surrounded by several border rows. The border rows and the single separating rows were inoculated (July 24) with a water suspension of conidia obtained from laboratory-grown cultures of Cercospora beticola.

The fungicide treatments commenced the 27th of July and were continued for five applications at ten-day intervals. All materials were applied with a Solo Port Mist Sprayer.

The following materials were used:

Fungicides	Rate per acre in 40 gals. of water
Copper A	4 pounds
Copper A	4 pounds plus 1 gallon oil
Manzate	$1\frac{1}{2}$ pounds
Manzate	$1\frac{1}{2}$ pounds plus 1 gallon oil
Dyrene	1 pound
Tri-Basic Copper Sulfate	4 pounds
Tri-Basic Copper Sulfate	4 pounds plus 1 gallon oil
T C - 90	1 gallon
Copper Oxychloride	2 pounds plus 1 gallon oil
Oil	1 gallon
Cyprex	$\frac{1}{2}$ pound

The fungicides were applied in water at the rate of 40 gallons of water per acre. Oil, where used, was added to the fungicide-water mixture at the rate of 1 gallon per acre. The check plot was treated with water at the rate of 40 gallons per acre.

Results:

Naturally occurring Cercospora leaf spot appeared in the field about July 20. On July 24, the separating and border rows were inoculated with conidia of *Cercospora beticola* harvested from laboratory cultures. The inoculum consisted of a mixture of several isolates of the fungus collected in several different sugar beet growing areas. In connection with this experiment, a new method was used to grow the fungus for spore production in the laboratory, and subsequent inoculation with the spores proved to be a successful method of inoculating sugar beets for disease tests with this organism.

Disease ratings were made the first week in September (table 1). The leaf spot ratings were somewhat higher this season than in the 1960 tests. I believe that the greater amount of infection was due to the new method of inoculation.

The disease ratings were significantly different at the 1-percent level using an F test (table 1). Copper A plus Oil and Tri-Basic Copper Sulfate plus Oil gave the best control. All of the fungicides gave good control, with the possible exception of TC-90. Oil with a fungicide did give the best control; Oil alone has less disease than the check. However, without any outstanding differences in the disease ratings and with this data representing only one test, too much significance should not be placed on the Oil effects; whereas the Copper A fungicide has given the best control for two successive years.

The sugar percentage data was not significant this year. There was considerable variation within the samples and only two samples per plot were taken for determinations.

The yield, tons per acre, was somewhat low in the experiment this year. There was a droughty condition during the last of July and early August. Copper A plus Oil was the only treatment which yielded significantly better than the check. It was not, however, significantly better than any of the other fungicide treatments. By ranking the data, Copper A plus Oil was the best treatment. In general the yield in all of the copper treatments, except TC-90 was good.

Summary:

The fungicide treatment, Copper A plus Oil, was the best in both yield and control of the disease. The copper fungicides, in general, gave the best control of the disease. With each fungicide treatment the addition of oil increased the fungicidial effect of the fungicide.

Table 1. The Sugar Beet Yield in Plots Treated Five Times with Different Fungicides at the Rosemount Experiment Station, 1961.

Treatments	Av. tons per acre	Ranked means level of significance * 5%	Av. % sugar	N.S.	Tons sugar per acre	Disease ratings**
Copper A	12.5	ab	12.3		1.54	2.25
Copper A + Oil	12.9*	a	13.7		1.77	2.00
Manzate	12.2	ab	11.6		1.42	2.50
Manzate + Oil	11.1	ab	12.8		1.42	2.25
Dyrene	12.0	ab	11.3		1.36	2.50
Tri-Basic Copper Sulfate	12.6	ab	12.5		1.58	2.50
Tri-Basic Copper Sulfate + Oil	12.5	ab	12.5		1.56	2.00
T C - 90	11.7	ab	12.0		1.40	3.00
Copper Oxychloride - Oil	11.0	ab	14.0		1.54	2.50
Oil	10.8	ab	12.3		1.33	3.75
Check (non-inoculated)	10.6	b	11.7		1.24	4.75
Cyprex	9.2	c	10.8		0.94	4.00

* Treatments not including similar letter are significantly different at the 5-percent level. (S-N-K multiple range test).

**Scale: 0 to 7; 0 no spots; 7 most of the leaves on a plant dead.

PART XIII

PHYSIOLOGICAL INVESTIGATIONS

Studies on Nitrogen Nutrition and Quality

Relation of Leaf Area to Sucrose Percentage
and Root Yield

Studies on Root Storage in Polyethylene Bags

Foundation Project 15

Myron Stout

C. H. Smith

F. W. Snyder

Research conducted in cooperation with Michigan Agricultural Experiment Station.

PHYSIOLOGICAL STUDIES RELATED TO NITROGEN NUTRITION AND QUALITY

By Myron Stout

GREENHOUSE STUDIES

A test was conducted to determine if "tip burn" could be induced by high nitrate nutrition prior to periods of low light intensity during the winter of 1960-61. A second purpose of the test was to determine if foliar applications of sugar or citrate might be used to prevent "tip burn" by aiding in the metabolism of the excess nitrate. Four hundred steckling beets of variety SL 0523 were planted in a ground bed 5 X 21 feet on November 29,1960; 200 pounds of N per acre as ammonium nitrate was applied to the soil before planting and the following applications were made in aqueous solution after planting:

January 11, 200 lbs. per acre

February 2, 300 lbs. peracre

February 16, 300 lbs. per acre

March 3, 500 lbs. per acre

A total of 1500 pounds of N per acre failed to induce appreciable "tip burn" in SL 0523. One of Dr. Owen's breeding lines in an adjacent room did develop some "tip burn" in 1961, suggesting that the tendency may be a genetic character--modified by nutritional and environmental factors.

Some nutritional deficiencies may develop in small beets early in the season, for reasons that are not readily apparent--see Schmidt Farm observation report, 1960. In such cases a foliar application might produce a rapid response if it could be applied without damaging the foliage. A small-scale test was conducted to determine how high a concentration of urea could be applied without foliar damage and if sugar added to the spray might reduce any damage caused by the urea. A bag of commercial urea (low in biuret) was used as the source of nitrogen. Concentrations up to 10% urea failed to produce appreciable burning

of the foliage, except in a few isolated cases where the leaves were cupped to retain an excessive quantity of the spray in liquid form. There were no consistent differences in growth of the plants, which were grown in highly fertile greenhouse soil and were periodically sprayed with any of the six different formulations.

FIELD TESTS

Soil profile samples were taken on two farms in Cache Valley in 1961. Comparisons were made between strips that were deeply re-cultivated in July and checks that were not re-cultivated.

Soil data show a considerably higher concentration of nitrate in the surface of the soil in strips that were re-cultivated than in the checks.

Yield and analytical data obtained on the plots in one field showed a higher average yield and higher sugar and purity of beets from the re-furrowed strips, although the data is based on only 36 15-feet-of-row samples. The average differences at both top and bottom of the field were similar. The beets on the other farm were harvested before samples were taken.

There were wide differences in surface nitrate concentration. The reasons for these large differences may be due to protection or lack of foliar protection of the soil surface during stormy weather. Fall rains were undoubtedly responsible to some extent for the lowest average sugar in several years in this area.

Report to Beet Sugar Development Foundation

F. W. Snyder, Plant Physiologist

I. Leaf Area in Relation to Sucrose Content and Size of Sugar Beet Roots.

Location: East Lansing, Michigan
Variety: Open-pollinated seed from one plant of US 401.
Date planted: May 3, 1961. Date harvested: October 16-20, 1961.
Experimental: Single plants grown in tiles 24" tall, 15" in diameter, containing 16" of builder's sand in bottom and 6" of vermiculite on top. Fed nutrient solution daily. The high nitrogen plants received nitrogen in the nutrient solution until harvest. The low nitrogen plants received no nitrogen after August 2 and had light green leaves after about September 1.

The data of Table 1 closely parallel that reported by Ulrich (Plant Physiology 30: 250-257. 1955.) Note that the weight of crown plus leaves was particularly increased late in the season by the continued feeding of nitrogen until harvest and, concomitantly, depressed sucrose accumulation. It is postulated that the low nitrogen plants failed to have a greater sucrose content because of too small leaf area.

Leaf area of specific plants included in the above data was determined up to 9 times during the growing season. Only the area of the primary leaves was determined during the growing season, but total leaf area was obtained at harvest. The area of the primary leaves reached a maximum in August or very early September and then gradually declined. Beginning in July, axillary leaves began to develop and increase in area until harvest. At harvest under high nitrogen, the area of the axillary leaves exceeded that of the primary leaves by as much as fourfold.

If 2 square centimeters is taken as an initial base for leaf area, during the growing season plant #1 doubled its leaf area more than 14 times, while plant #6 doubled its leaf area over 12 times. See Table 2 for leaf areas of these plants at harvest.

The data in Table 2 reveal that leaf area on August 1 correlates better with root weight and sucrose content than leaf area at harvest. This suggests that leaf area in the latter part of the season is less critical in determining yield and sucrose than has been suspected. Removal of nitrogen on August 2 failed to reduce yield as much as might have been anticipated.

II. Influence of Nitrogen Nutrition on Transport of Carbon-14 from the Leaf of Sugar Beet Fed $C^{14}O_2$ in Sunlight.

Cooperator in research: N. E. Tolbert, Department of Biochemistry,
Michigan State University, East Lansing, Michigan.
Location: Outdoors, East Lansing, Michigan, 1961 growing season.

Table 1. Influence of nitrogen on sugar beet performance.

Plant part	Averages* for Low nitrogen	Averages* for High nitrogen	Range* in values for Low nitrogen	Range* in values for High nitrogen
Leaves, weight in grams	856	1,567	270 - 2,404	632 - 3,068
Crown, weight	515	841	232 - 827	369 - 1,722
Root, weight	2,008	1,665	1,365 - 2,615	834 - 3,155
Root + crown, weight	2,523	2,507	1,708 - 3,261	1,203 - 4,070
Total plant, weight	3,379	4,073	2,228 - 5,665	2,389 - 6,528
Root/shoot ratio**	1.47	0.69	0.86 - 2.63	0.29 - 1.32
Sucrose percentage	14.4	10.4	13.1 - 15.3	8.2 - 12.4

* Data based on 7 plants on low nitrogen and 16 plants on high nitrogen.
** Shoot is defined as crown plus leaves; the root being the portion below the bottom leaf-scar.

Table 2. Relation of leaf area to root weight and sucrose content for individual plants.

Plant number	Nitrogen nutrition	Leaf area August 1*	Leaf area Harvest**	Root Weight	Sucrose concentration		Ratio of Leaf area/sucrose August 1	Ratio of Leaf area/sucrose Harvest
		Cms.^{2}	Cms.^{2}	Grams	Percent	Grams	Cms.^{2}/gm.	Cms.^{2}/gm.
1	High	7,900	27,082	2,390	12.3	294.0	26.9	92.1
2	High	7,530	15,403	3,155	10.9	343.9	21.9	44.8
12	High	6,330	9,353	1,412	12.4	175.1	36.2	53.4
6	High	3,120	7,599	1,074	9.0	96.7	32.3	78.6
10	Low	8,230	4,533	2,195	13.8	302.9	27.2	15.0
20	Low	7,900	5,328	1,856	15.3	284.0	27.8	18.8
9	Low	7,320	1,914	1,652	14.5	239.5	30.6	8.0
30	Low	5,820	8,099	1,793	14.6	261.8	22.2	30.9

* Area of primary leaves.
** Area of all leaves.

Experimental: Vegetative cuttings of a clone were grown in tiles 24" tall, 15" in diameter with 16" of builder's sand in the bottom and 6" of vermiculite on top. Fed nutrient solution daily.
Nitrogen status: High nitrogen plants received nitrogen in nutrient solution until harvest. The low nitrogen plants received no nitrogen after August 2. Approximately a millicurie of carbon-14 as $C^{14}O_2$ was fed to a sugar beet enclosed in a plexiglass chamber. One hour after initiation of feeding, the chamber was removed and a nearly mature leaf was harvested, separated into blade and petiole and each killed in boiling 80% ethyl alcohol. The percent of carbon-14 in the petiole of the leaf from a plant on high nitrogen was compared with that from a plant receiving no nitrogen after August 2. The data are given below.

Date experiment performed	Percent of carbon-14 in petiole of plant on High nitrogen	Low nitrogen	Ratio of Low/High
Sept. 19	3.89	11.01	2.83
Sept. 21	7.29	21.22	2.91
Oct. 9	6.72	11.27	1.68
Oct. 10	9.22	12.73	1.38
Oct. 31	6.80	7.84	1.15
Nov. 1	4.28	10.01	2.34

Comments: The more rapid transport of carbon from the leaves of sugar beets on low nitrogen may explain why they have more sugar in their roots than those on high nitrogen. Chromatographic data will be available at a later date.

III. Effect of Leaf Removal on Yield and Sucrose of Sugar Beets on 2 Levels of Nitrogen.

Cooperator in research: Mark Berrett, Farmers and Manufacturers Beet Sugar Association, Saginaw, Michigan.
Location: Elmer Rader Farm, Saginaw, Michigan.
Variety: Commercial monogerm (SL 122 x 5460).
Date planted: May 19, 1961. Date harvested: October 5, 1961.
Crop and Fertilizer History: 1960 Corn 400# 10-20-10, 1961 Sugar Beets 400# 10-20-10 banded at planting time.

Experimental design and treatments: Randomized plots, 21 feet long, 4 rows wide (28" row width), 3 replications of each treatment. All rows harvested, weighed and sampled for sugar. Two levels of nitrogen: 0 and 100# sidedressed on July 6. Within each nitrogen level following treatments:

1. Control - no leaf removal
2. Removal of $\frac{1}{2}$ of each leaf as it developed, beginning June 30 and at 2 week intervals through September 22.
3. Removal of $\frac{1}{2}$ of total number of leaves (based on number of leaves on plants in control plot) at same time as in treatment 2. The outer, large leaves were removed.

Treatment	Nitrogen sidedressing applied 0 # per acre		100 # per acre	
	Ave. wt. per beet	Sucrose percentage	Ave. wt. per beet	Sucrose percentage
Control	1.96	16.65	1.98	15.38
$\frac{1}{2}$ of each leaf removed	1.60	16.11	1.71	14.95
$\frac{1}{2}$ total no. leaves removed	1.36	15.35	1.46	14.16

Significance of data: When the sucrose percentage of commercial sugar beets averaged less than 14 percent, this late planted and early harvested experiment with limited amount of nitrogen produced beets having 16.6 percent sucrose without a reduction in tonnage. Addition of 100 # of nitrogen as a sidedressing failed to increase yield but depressed sucrose to 15.4 percent. Under 1961 Michigan conditions, removal of approximately half the leaf area reduced both tonnage and sucrose at the 2 levels of nitrogen nutrition.

PRELIMINARY STUDIES OF SUGAR BEET ROOT STORAGE IN POLYETHYLENE BAGS

By C. H. Smith

A test at Salt Lake City during the winter of 1960-61 indicated that polyethylene bags may be used successfully for root storage of certain vigorous sugar beet hybrids and varieties. Further experiments are being conducted in the refrigerated beet storage room at Logan, Utah. However, bad storage was experienced with the same polyethylene bags when an attempt was made to store certain inbred lines and certain hybrids with these lines. Size of root was not a factor, and washed as well as unwashed beets showed no significant difference. The important difference appeared to be varietal origin.

The successful use of 2 mil polyethylene bags by strawberry breeders led to a preliminary study of their use in the storage of sugar beet roots. Polyethylene bags of 1-1/2 mil and 2 mil thickness were used. Both washed and unwashed beets were placed in the bags and stored in a root cellar where the temperature was maintained at 38° to 40°F. Sphagnum moss was placed in some of the bags for the purpose of taking up excess moisture that might collect from transpiration of the beets.

On March 1, 1961, nearly four months after storage began, the beets were carefully examined for spoilage. All roots were turgid, showing no appreciable effects of dehydration. Beets from number 211H3 showed signs of slight crown tissue disintegration. One beet was discarded because of crown rot and some others required slight trimming of the crown area. Beets from the monogerm derivative 0224 (both CT5 and CT9 parentage) were in perfect condition, showing no signs of either root or crown deterioration. Beets in CT5 derivatives, lots 0523, 0267 and 0156, showed advanced stages of crown deterioration. Many beets were discarded and the remainder required severe trimming of affected areas.

Previous experience of storing steckling-sized beets in ground trenches had proved satisfactory for most varieties. Occasionally a variety showed poor storageability unless trenches were opened up at an early date to allow more adequate aeration. Improved techniques in trench storage have alleviated some of this trouble. Results shown in this test indicate that possibly oxygen requirements or some other physiological makeup of the sugar beet differ with varieties and may limit root storage in polyethylene bags to beet varieties with rather low transpiration during low temperature storage.

Storage of spring-planted beets in the root cellar had its problems. The preliminary tests shown here with mature beets include previously tried methods in comparison with the use of polyethylene sheeting as a covering and in the form of bags. Beets remained turgid in all instances except in the top corner of the storage bin where the polyethylene sheeting had not sealed out free-flowing air from the beets. In this instance beets did show marked signs of dehydration. Where the sheeting was tightly held in place and more than one thickness covered the beets, molds appeared which would eventually lead to serious decomposition of the roots. In all seven treatments of mature roots in this test, minor spots of rot appeared and were not confined to the crown area as much as it appeared to be in the steckling-sized roots.

This method of storage may aid in improving better storageability in sugar beet varieties. The storage of roots in polyethylene bags is convenient for greenhouse use in that the roots are more accessible during winter months. Further studies are necessary to determine additional information about these and other factors involved in obtaining adequate storage of sugar beet roots.

ROOT CELLAR STORAGE OF STECKLING-SIZED BEET ROOTS

Variety	Planting date	Thickness of poly-ethylene bag	Number of beets	Treatment of roots prior to storage	Sphagnum moss in bag with beets	Date stored	Condition of roots March 1, 1961
211H3	Early August	2 mil	28	Washed	Yes	Nov. 10	1 disc.; crown rot; little trimming
		2 mil	28	do.	No	do.	No rot; do.
		2 mil	28	do.	No	do.	do. do.
		1-1/2 mil	16	do.	No	do.	do. very good
0224	Late August	2 mil	29	Washed	Yes	Nov.22	No rot; perfect storage
		1-1,2 mil	20	do.	Yes	do.	do. do.
		2 mil	28	Unwashed	Yes	do.	do. do.
		1-1/2 mil	20	do.	Yes	do.	do. do.
0523	Late August	2 mil	13	Washed	Yes	Nov. 22	2 disc.; crown rot; trimming severe
		1-1/2 mil	12	do.	Yes	do.	5 disc.; do.
		2 mil	13	Unwashed	Yes	do.	7 disc.; do.
		1-1/2 mil	13	do.	Yes	do.	4 disc.; do.
0267	Late August	2 mil	14	Washed	Yes	do.	5 disc.; do.
		1-1/2 mil	13	do.	Yes	do.	4 disc.; do.
		2 mil	13	Unwashed	Yes	do.	5 disc.; do.
		1-1/2 mil	13	do.	Yes	do.	2 disc.; do.
0156	Late August	1-1/2 mil	22	Washed	Yes	Nov. 15	4 disc.; do.

ROOT CELLAR STORAGE OF STECKLING-SIZED SUGAR BEET ROOTS
DATE STORAGE BEGAN -- November 17, 1960
END STORAGE PERIOD -- April 18, 1961

VARIETY	Polyethylene bag thickness	Number of beets	Treatment roots prior to storage	Sphagnum moss as packing	BEETS SAVED Crown rot	Root rot	No rot	Total saved	Beets discarded	Misc. notes
211H3	2 mil.	27	Washed	Yes	10	2	15	27	0	Top growth suppressed more evidence of crown disintegration than root rots
	"	28	"	no	7	3	18	28	0	
	"	28	"	no	1	2	25	28	0	
	1-1/2 mil.	16	"	no			16	16	0	
0224	2 mil.	29	Washed	Yes	7		21	28	1	Spoilage was light in nature and bad areas easily trimmed off
	1-1/2 mil.	20	"	"	1		19	20	0	
	2 mil.	28	not washed	"			28	28	0	
	1-1/2 mil.	20	" "	"		2	17	19	1	
0523	2 mil.	11	Washed	Yes	1		2	3	8	Crowns go bad first
	1-1/2 mil.	7	"	"					7	all gone bad
	2 mil.	6	Not washed	"	1		3	4	2	
	1-1/2 mil.	9	" "	"			4	4	5	Crowns go bad first
0267	2 mil.	9	Washed	Yes	1	1	1	3	6	
	1-1/2 mil.	9	"	"		2	5	7	2	Some dark spots showing on skin
	2 mil.	8	Not washed	Yes			7	7	1	Tops disintegrating
	1-1/2 mil.	11	" "			5	5	10	1	
0156	1-1/2 mil.	18	Washed	Yes				12	6	Skin darkening - crown rot most prevalent Growth suppressed Roots turgid

STORAGE OF MISC. SPRING-PLANTED SUGAR BEET ROOTS
DATE STORAGE BEGAN - November 17, 1960
END OF STORAGE - April 18, 1961

Type of storage	Number of beets	BEETS SAVED CROWN ROT	ROOT ROT	NO ROT	TOTAL SAVED	BEETS DISCARDED	MISC. NOTES
1	55	2		44	46	9	Some mold present, beets good in general
2	52				51	1	No mold -- beets look good
3	30				29	1	Godd condition
4					50%	50%	Beets with hollow crowns appear to go bad quickly. Mold present where Pol. sheet touched beets
5	12				12	0	No mold - no rot. Good condition
6	12	2	2	5	9	3	No mold
7	23	5	10	7	22	1	No mold - top growth suppressed
8	17	5	1	10	16	1	No mold - some top growth

KEY TO TYPE OF STORAGE USED ON MISCELLANEOUS SUGAR BEET ROOTS

1 = Lettuce crate wrapped in 2 mil. polyethylene sheeting - no packing

2 = Lettuce crate lined with paraffin paper - beets packed in shavings

3 = Beets stored in trench - boards, straw and soil over top of trench with tile vent -- beets packed in soil around root

4 = Beets stored in bin - covered with polyethylene sheeting - no packing

5 = Beets stored in polyethylene bags 1-1/2 mil. thickness - packed in sphagnum moss

6 = " " " " 1-1/2 " " - no packing

7 = " " " " 2 mil. " - packed in sphagnum moss

8 = " " " " 2 mil. " - no packing